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**Picker**

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(45) **Date of Patent: *Mar. 29, 2016**

(54) **ARCHITECTURE, DEVICES AND METHODS FOR SUPPORTING MULTIPLE CHANNELS IN A WIRELESS SYSTEM**

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(72) Inventor: **Dan Picker**, San Diego, CA (US)

(73) Assignee: **Redline Communications Inc.**, Markham (CA)

( * ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

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(22) Filed: **Oct. 23, 2014**

(65) **Prior Publication Data**

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**Related U.S. Application Data**

(63) Continuation of application No. 13/235,569, filed on Sep. 19, 2011, now Pat. No. 8,891,464.

(51) **Int. Cl.**

| | |
|---|---|
| ***H04W 4/00*** | (2009.01) |
| ***H04W 72/04*** | (2009.01) |
| ***H04W 88/08*** | (2009.01) |
| *H04B 7/06* | (2006.01) |
| *H04B 7/08* | (2006.01) |

(52) **U.S. Cl.**

CPC ..... ***H04W 72/0453*** (2013.01); ***H04B 7/0689*** (2013.01); ***H04B 7/0871*** (2013.01); ***H04W 88/08*** (2013.01); *H04B 7/0671* (2013.01); *H04B 7/0857* (2013.01)

(58) **Field of Classification Search**

None

See application file for complete search history.

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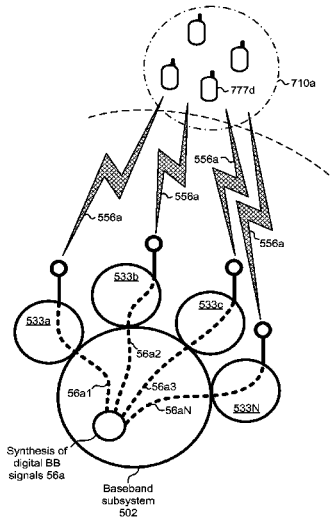
*Primary Examiner* — Michael J Moore, Jr.

(74) *Attorney, Agent, or Firm* — Nixon Peabody LLP

(57) **ABSTRACT**

Devices, systems, and methods are presented for a wireless base station to assign dynamically a plurality of radio transceiver chains among a varying number of wireless channels. In this manner, the communication system including the wireless base station may transition between a range extension mode and an enhanced capacity mode. In the range extension mode, a system is configured for maximum communication range with Subscriber Stations that are relatively distant from the radio transceiver chains, although communication is still possible with nearby Subscriber Stations. In the enhanced capacity mode, the system is configured for maximum communication throughput with Subscriber Stations that are relatively near to the radio transceiver chains, whereas communication with relatively distant Subscriber Stations will be either terminated or at least non-optimized.

**2 Claims, 27 Drawing Sheets**



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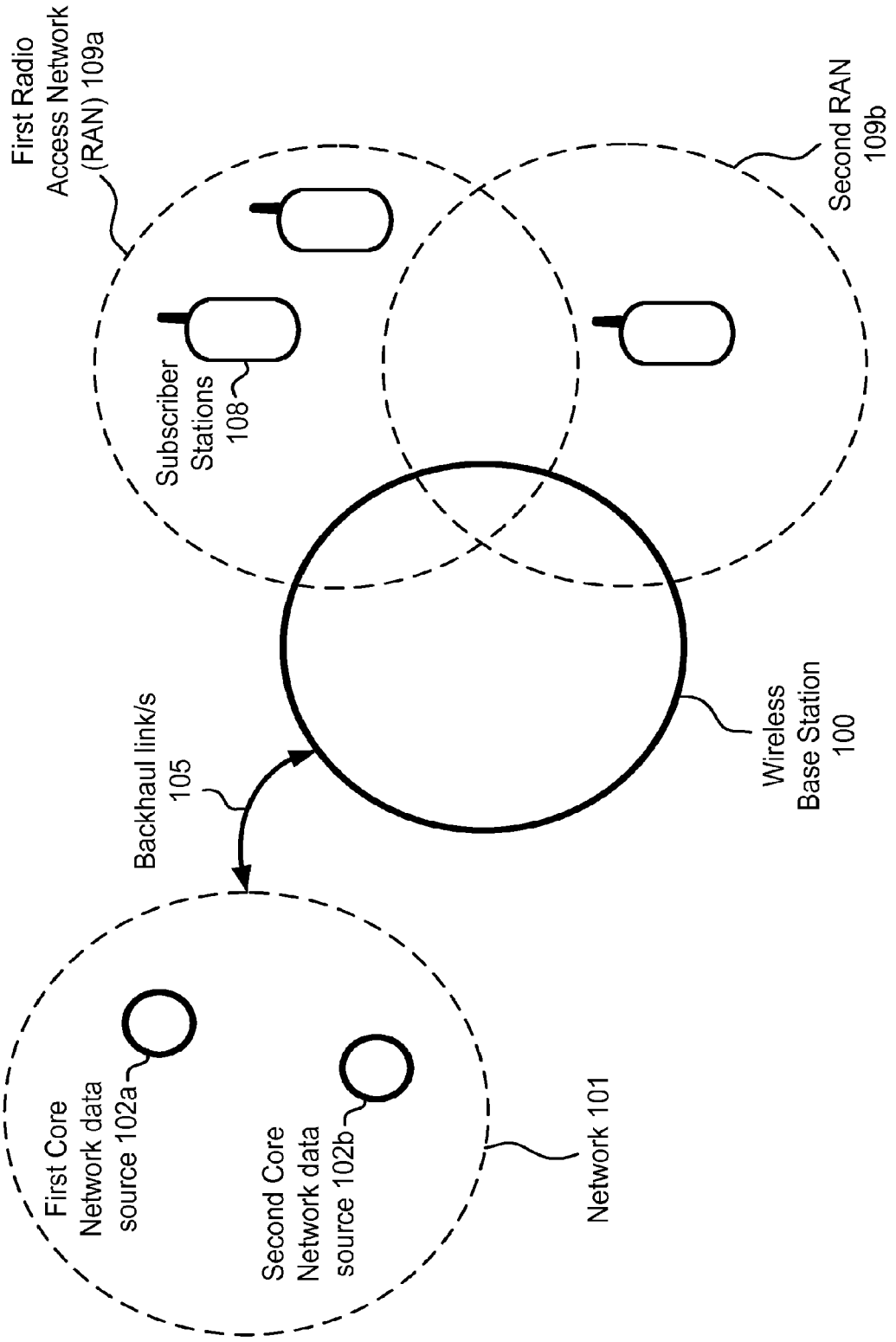
First Radio Access Network (RAN) 109a
Second RAN 109b
Subscriber Stations 108
Backhaul link/s 105
Wireless Base Station 100
First Core Network data source 102a
Second Core Network data source 102b
Network 101

FIG. 1A

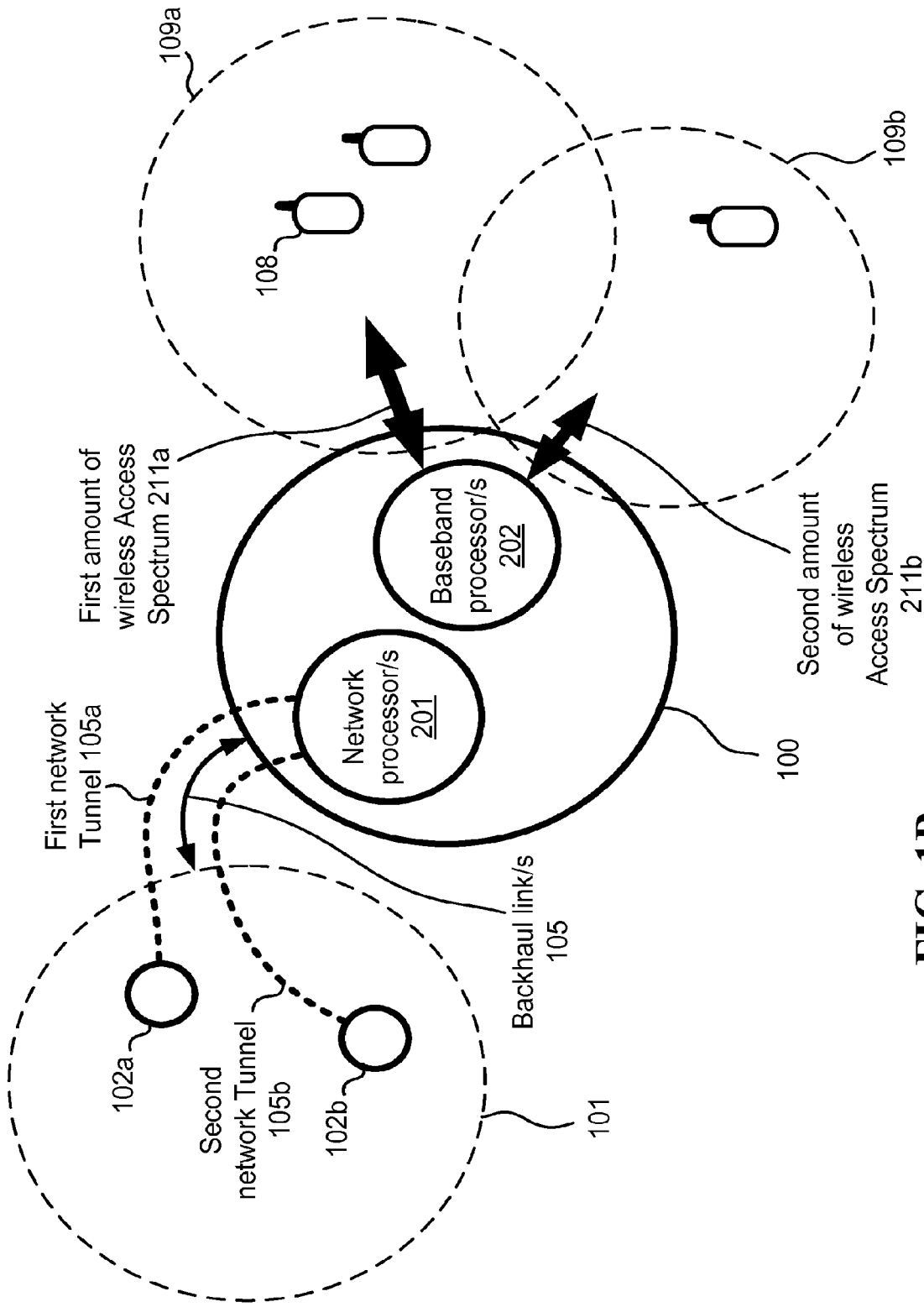
109a
108
109b
First amount of wireless Access Spectrum 211a
Second amount of wireless Access Spectrum 211b
Baseband processor/s 202
Network processor/s 201
100
First network Tunnel 105a
Backhaul link/s 105
102a
Second network Tunnel 105b
102b
101

FIG. 1B

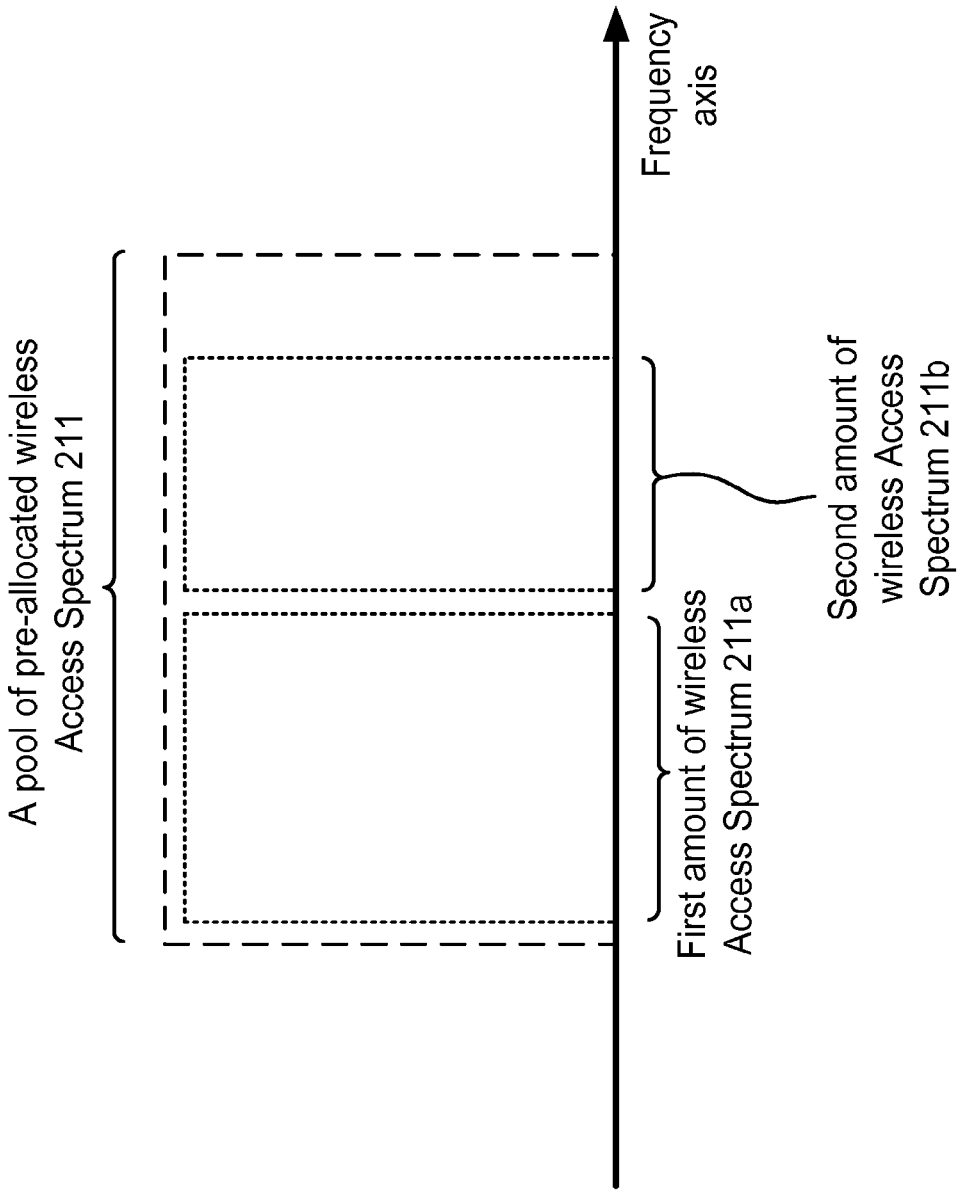
A pool of pre-allocated wireless Access Spectrum 211
Frequency axis
First amount of wireless Access Spectrum 211a
Second amount of wireless Access Spectrum 211b

FIG. 1C

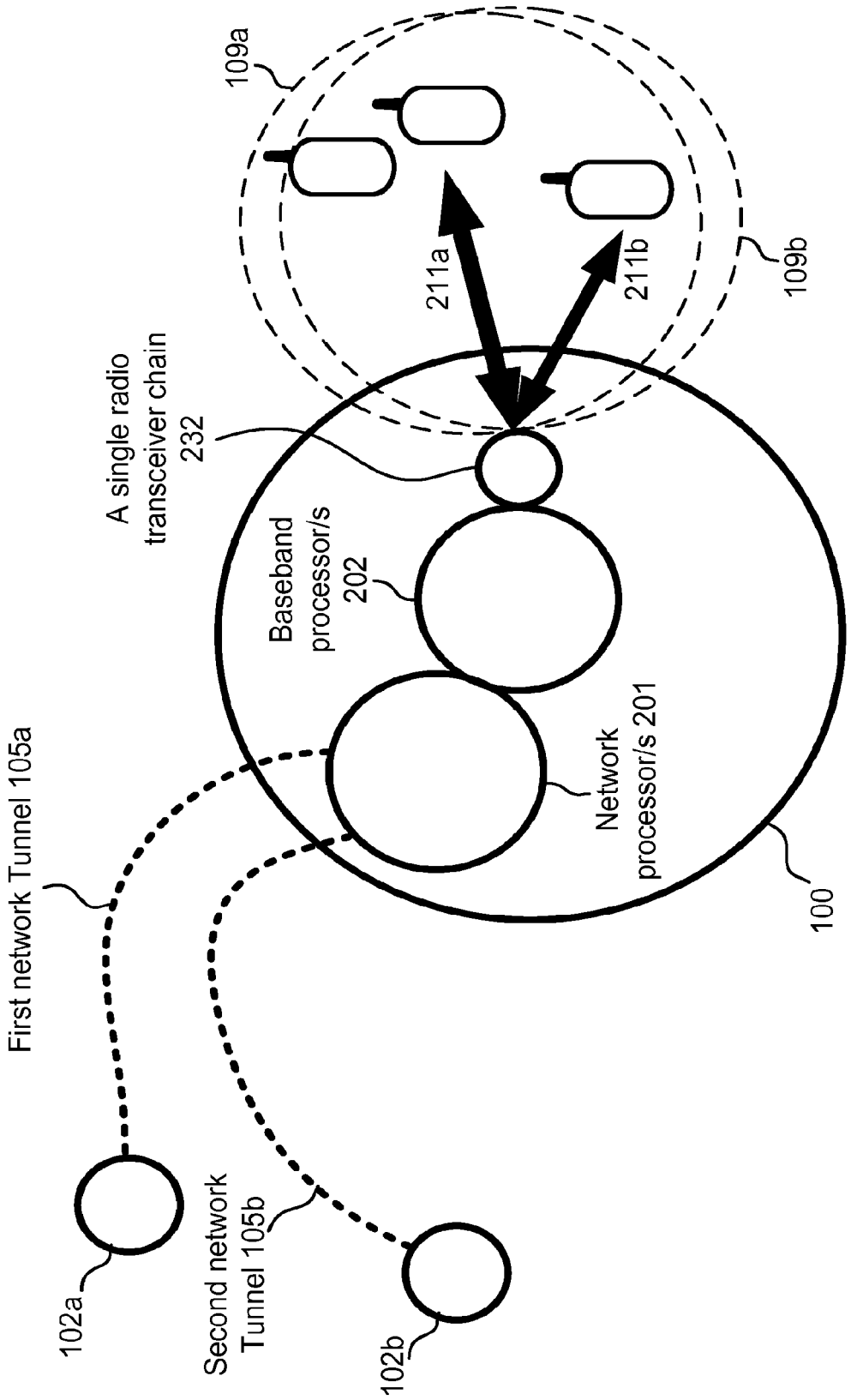
109a
211a
211b
109b
A single radio transceiver chain 232
Baseband processor/s 202
Network processor/s 201
100
First network Tunnel 105a
Second network Tunnel 105b
102a
102b

FIG. 2

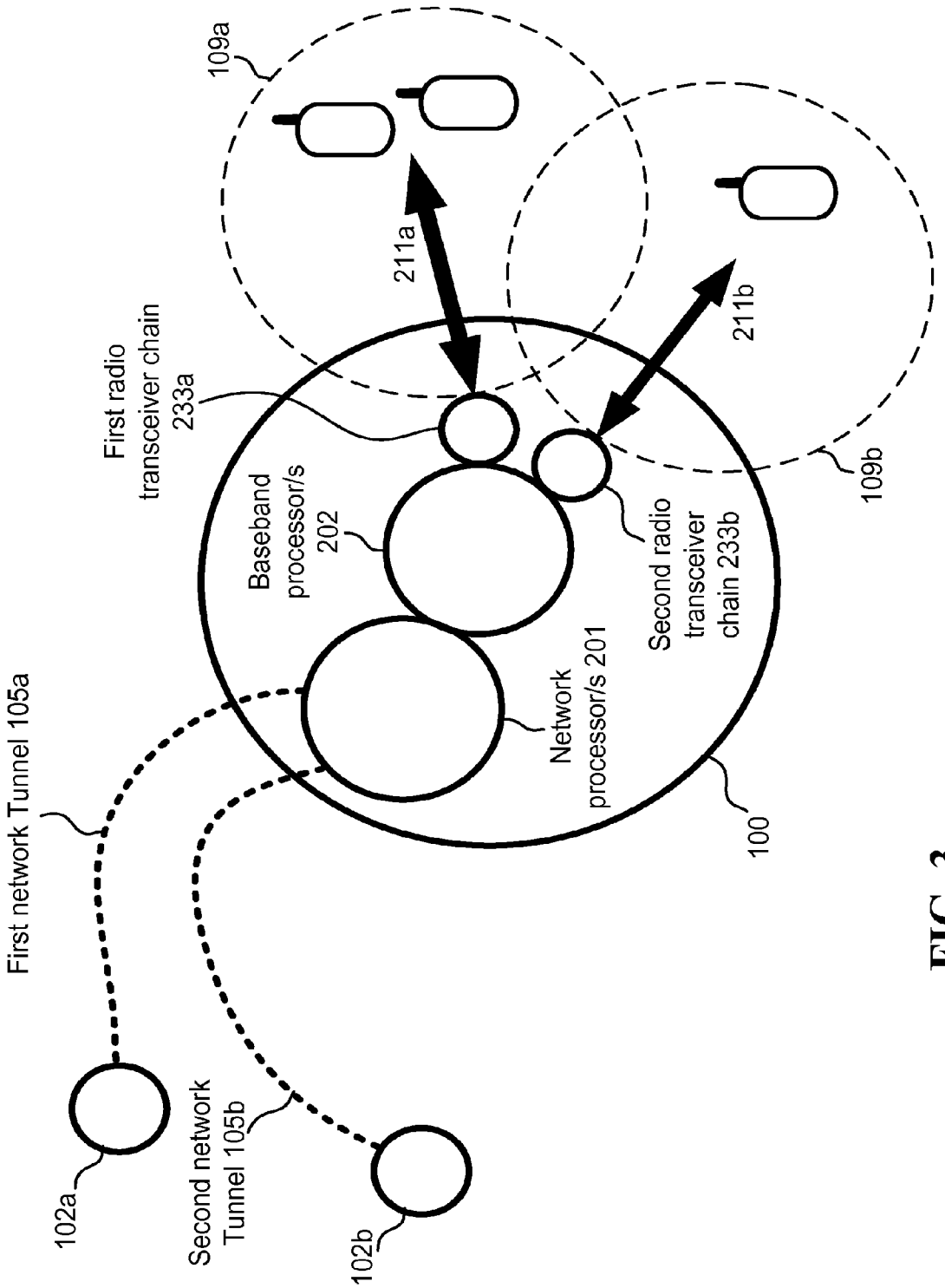
109a
211a
211b
First radio transceiver chain 233a
Baseband processor/s 202
Second radio transceiver chain 233b
109b
Network processor/s 201
100
First network Tunnel 105a
Second network Tunnel 105b
102a
102b

FIG. 3

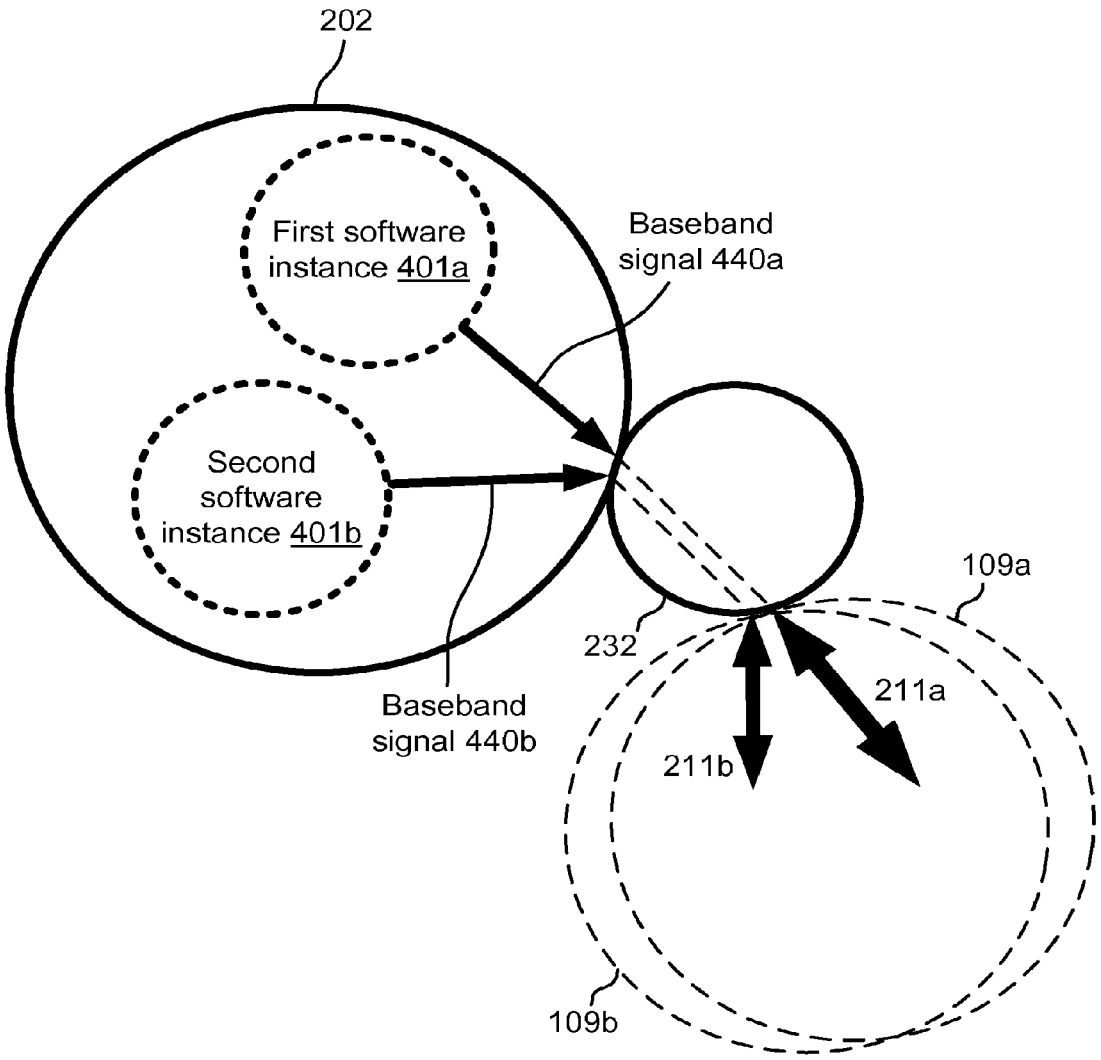
202
First software instance 401a
Baseband signal 440a
Second software instance 401b
Baseband signal 440b
232
109a
211a
211b
109b

FIG. 4

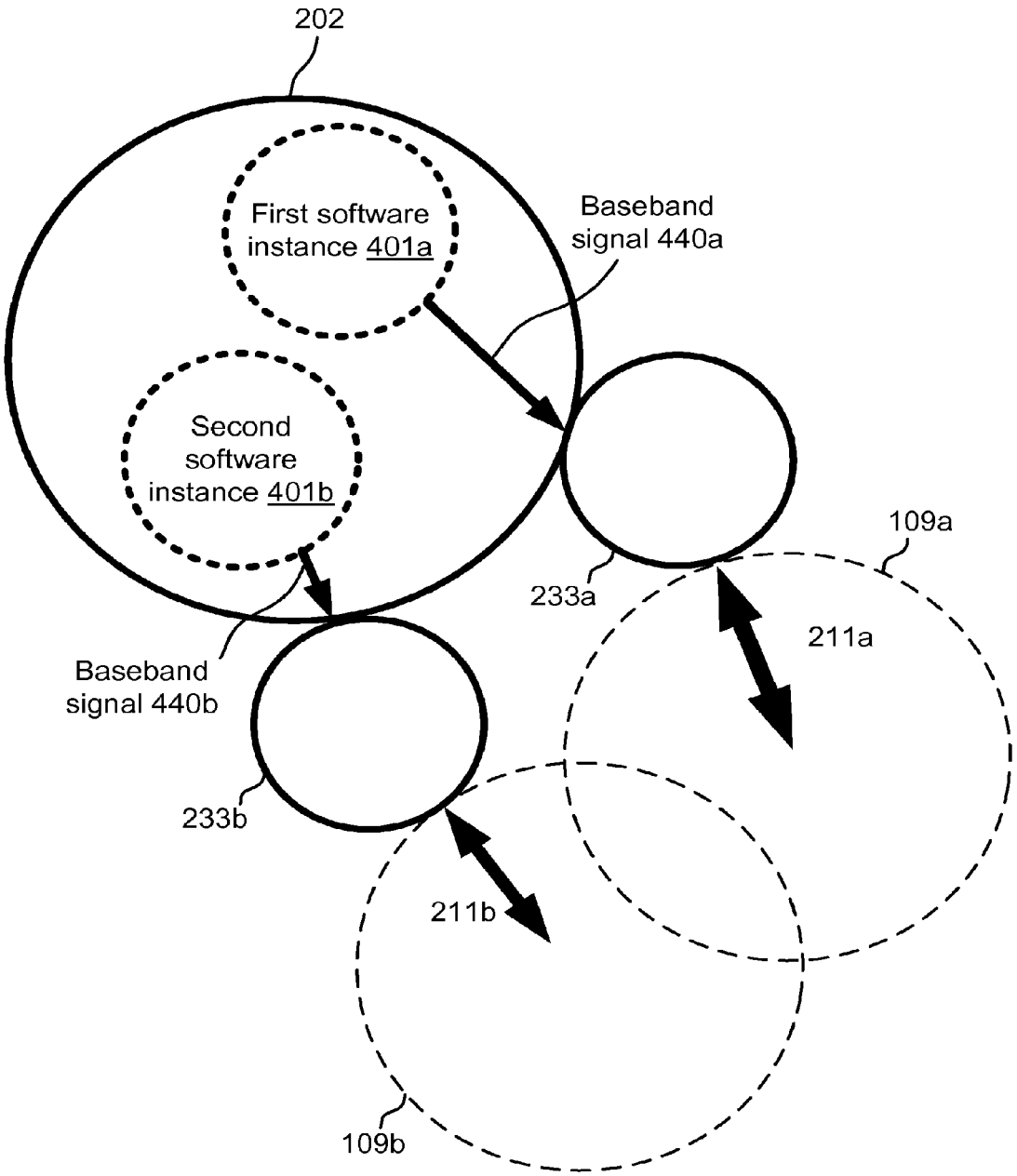
202
First software instance 401a
Second software instance 401b
Baseband signal 440a
Baseband signal 440b
233a
233b
109a
109b
211a
211b

FIG. 5

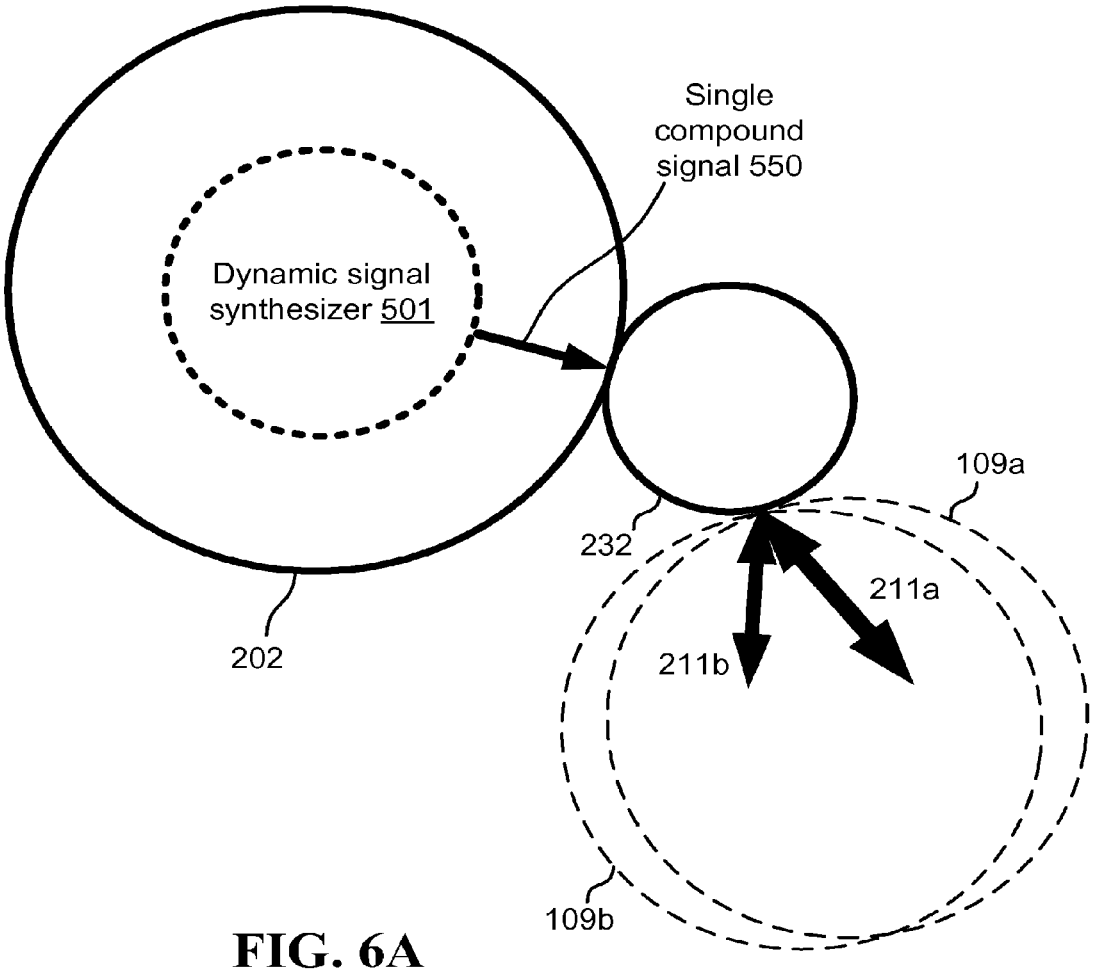
Single
compound
signal 550
Dynamic signal
synthesizer 501
109a
232
211a
211b
202
109b

FIG. 6A

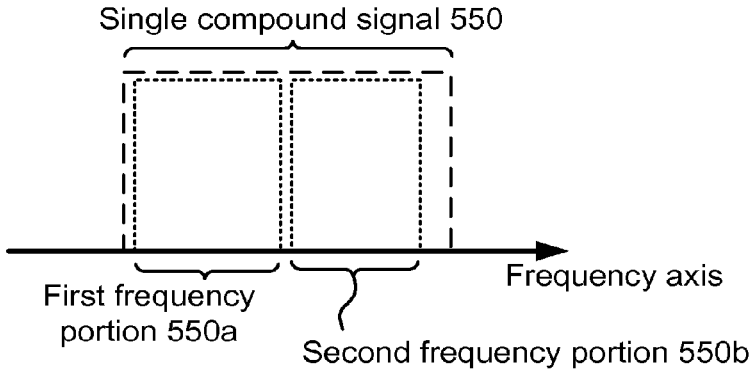
Single compound signal 550
Frequency axis
First frequency
portion 550a
Second frequency portion 550b

FIG. 6B

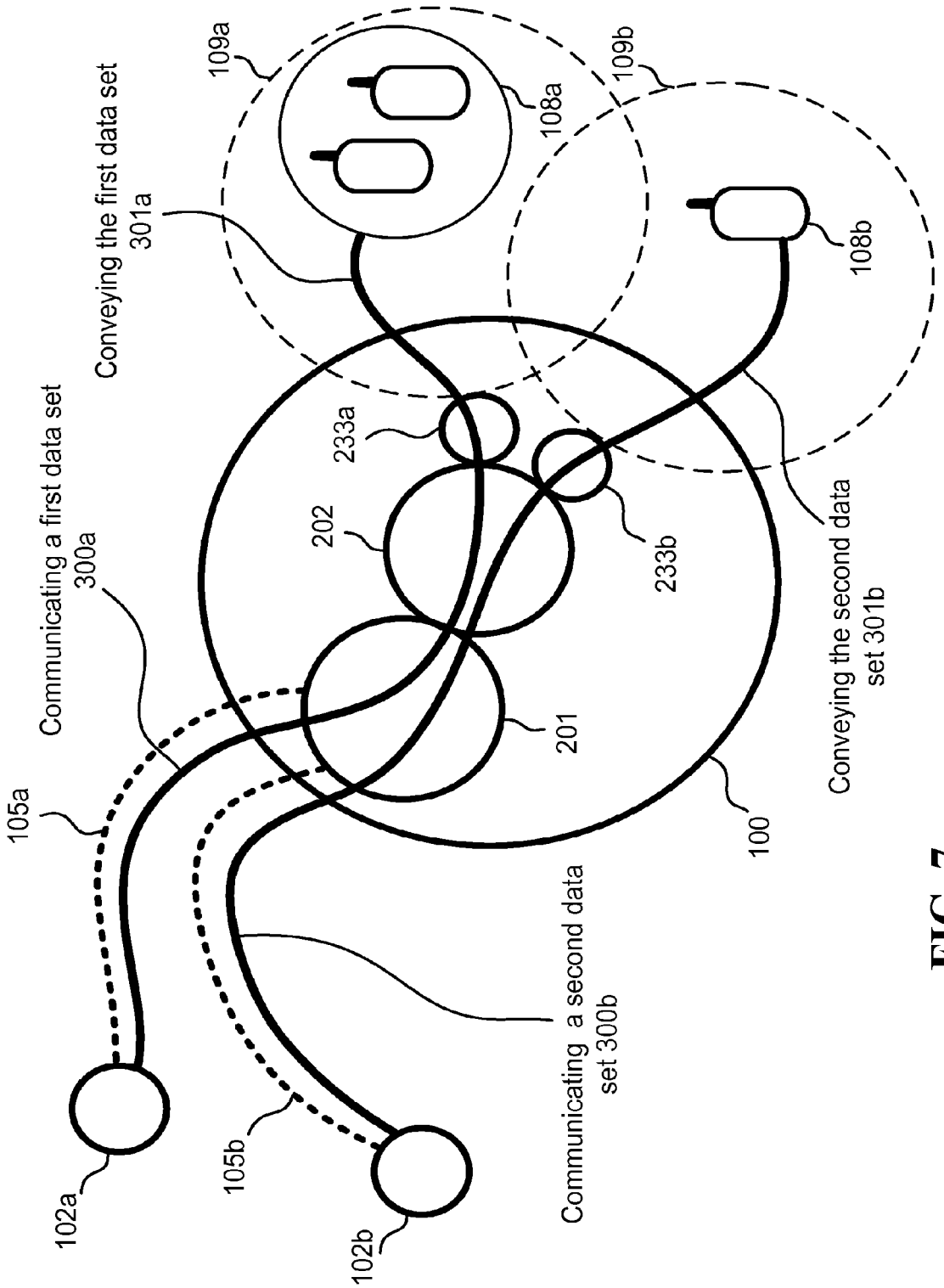
Communicating a first data set 300a
Conveying the first data set 301a
Conveying the second data set 301b
Communicating a second data set 300b
105a
105b
102a
102b
100
201
202
233a
233b
108a
108b
109a
109b

FIG. 7

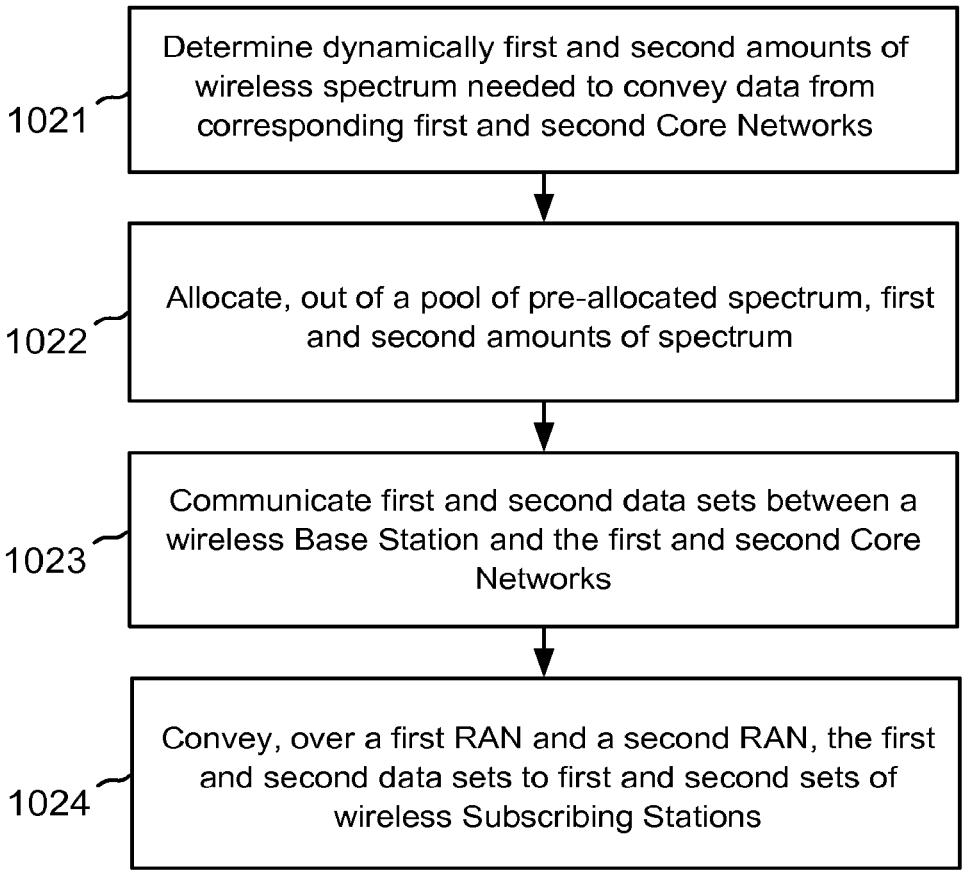
1021
Determine dynamically first and second amounts of wireless spectrum needed to convey data from corresponding first and second Core Networks
1022
Allocate, out of a pool of pre-allocated spectrum, first and second amounts of spectrum
1023
Communicate first and second data sets between a wireless Base Station and the first and second Core Networks
1024
Convey, over a first RAN and a second RAN, the first and second data sets to first and second sets of wireless Subscribing Stations

FIG. 8

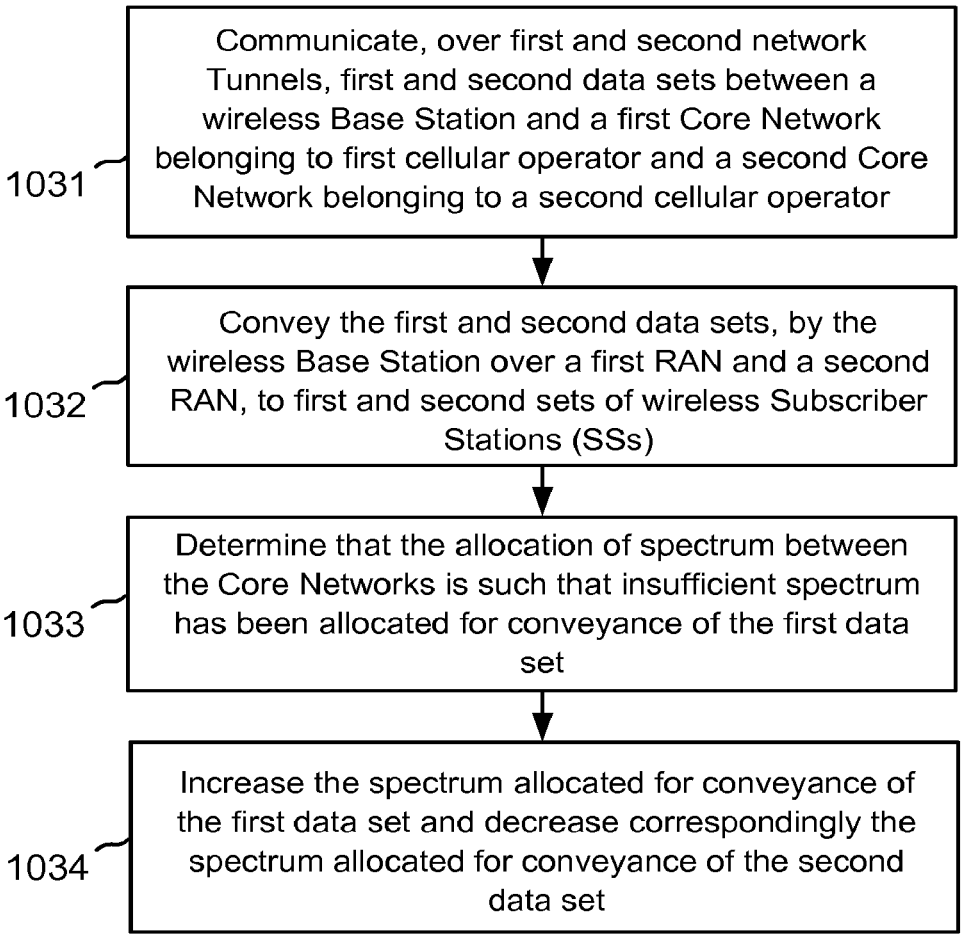
Communicate, over first and second network Tunnels, first and second data sets between a wireless Base Station and a first Core Network belonging to first cellular operator and a second Core Network belonging to a second cellular operator
1031
Convey the first and second data sets, by the wireless Base Station over a first RAN and a second RAN, to first and second sets of wireless Subscriber Stations (SSs)
1032
Determine that the allocation of spectrum between the Core Networks is such that insufficient spectrum has been allocated for conveyance of the first data set
1033
Increase the spectrum allocated for conveyance of the first data set and decrease correspondingly the spectrum allocated for conveyance of the second data set
1034

FIG. 9

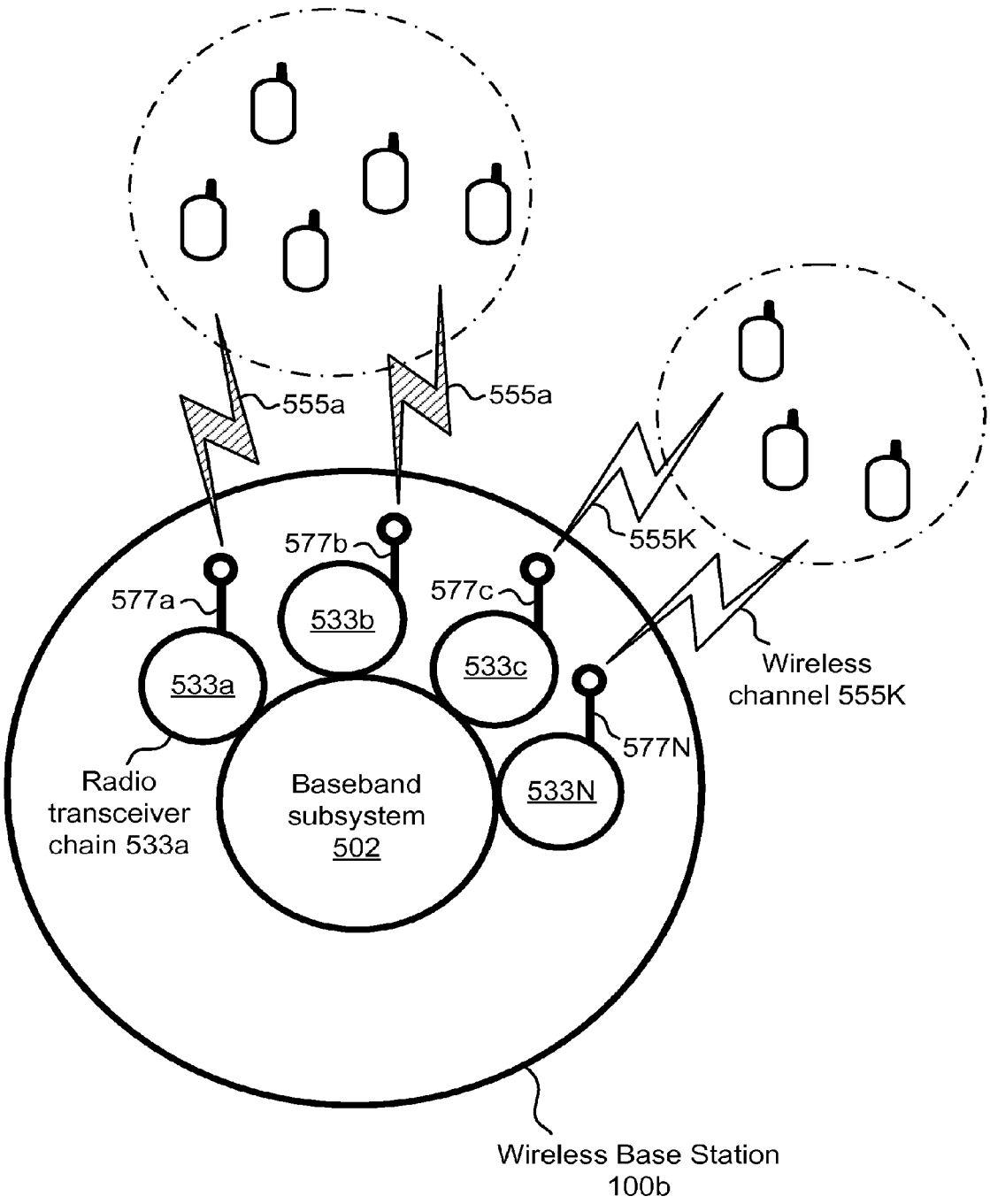
555a
555a
555K
577a
577b
577c
577N
533a
533b
533c
533N
Radio transceiver chain 533a
Baseband subsystem 502
Wireless channel 555K
Wireless Base Station 100b

FIG. 10A

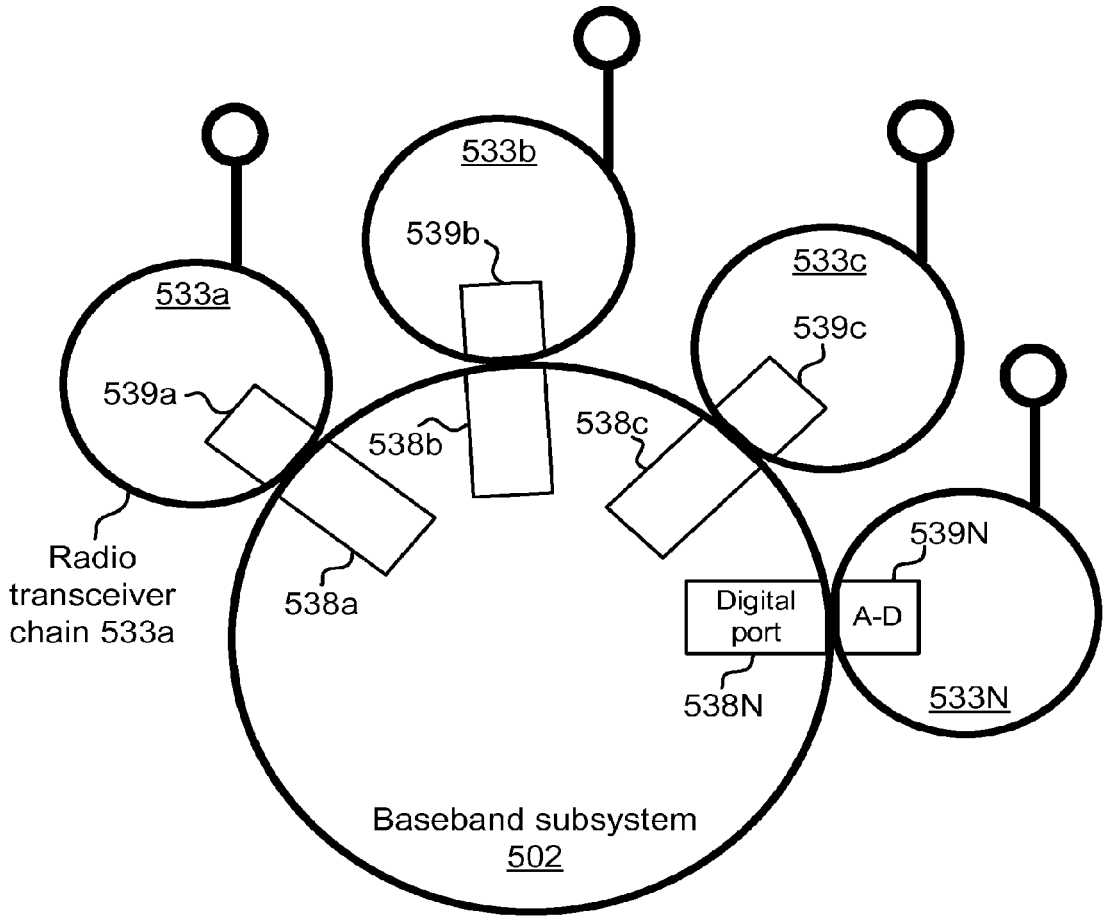
533b
539b
533a
533c
539c
539a
538b
538c
Radio transceiver chain 533a
538a
539N
Digital port
A-D
538N
533N
Baseband subsystem 502

FIG. 10B

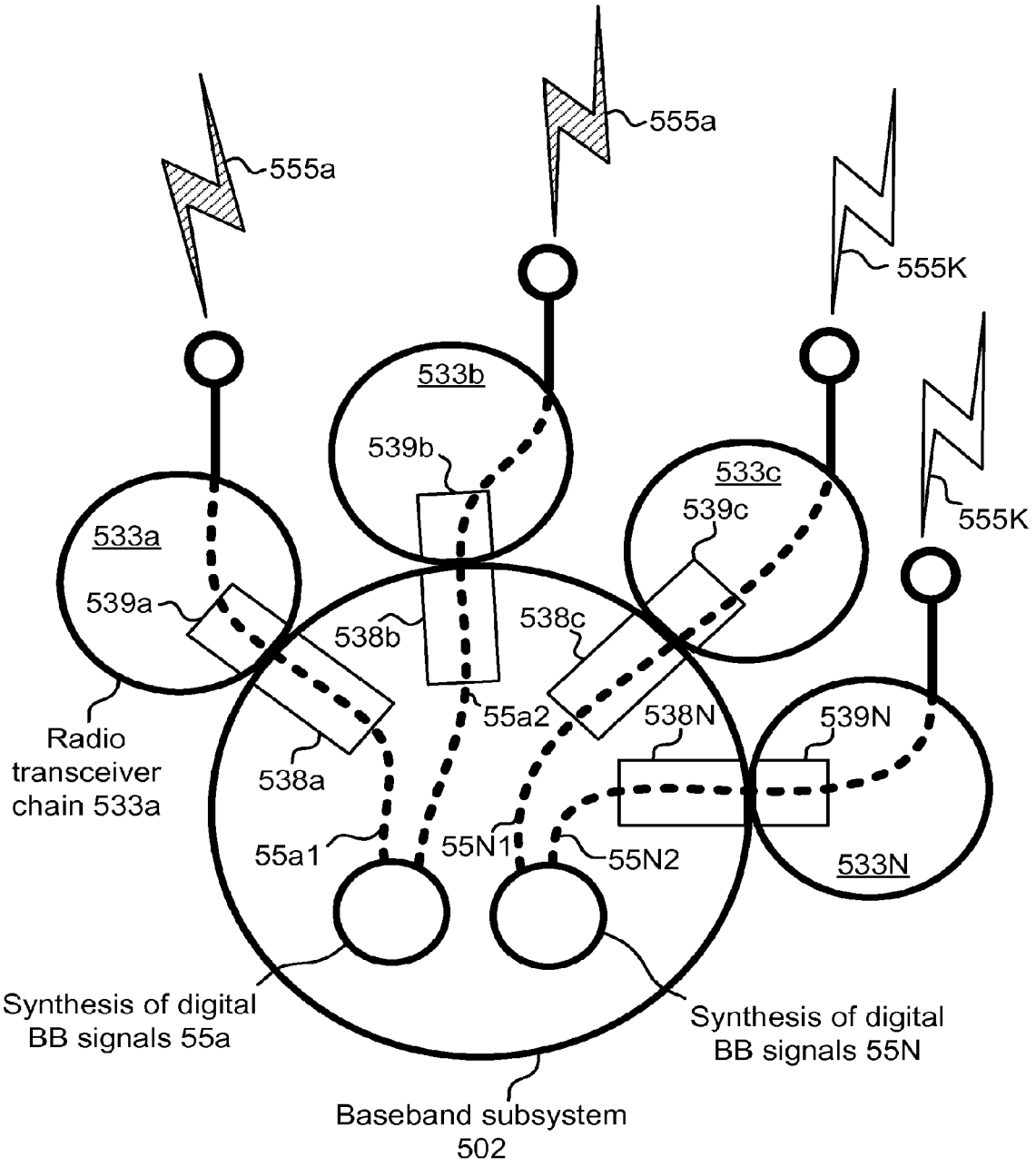
555a
555a
555K
555K
533b
539b
533c
539c
533a
539a
538b
538c
55a2
538N
539N
Radio transceiver chain 533a
538a
55a1
55N1
55N2
533N
Synthesis of digital BB signals 55a
Synthesis of digital BB signals 55N
Baseband subsystem 502

FIG. 10C

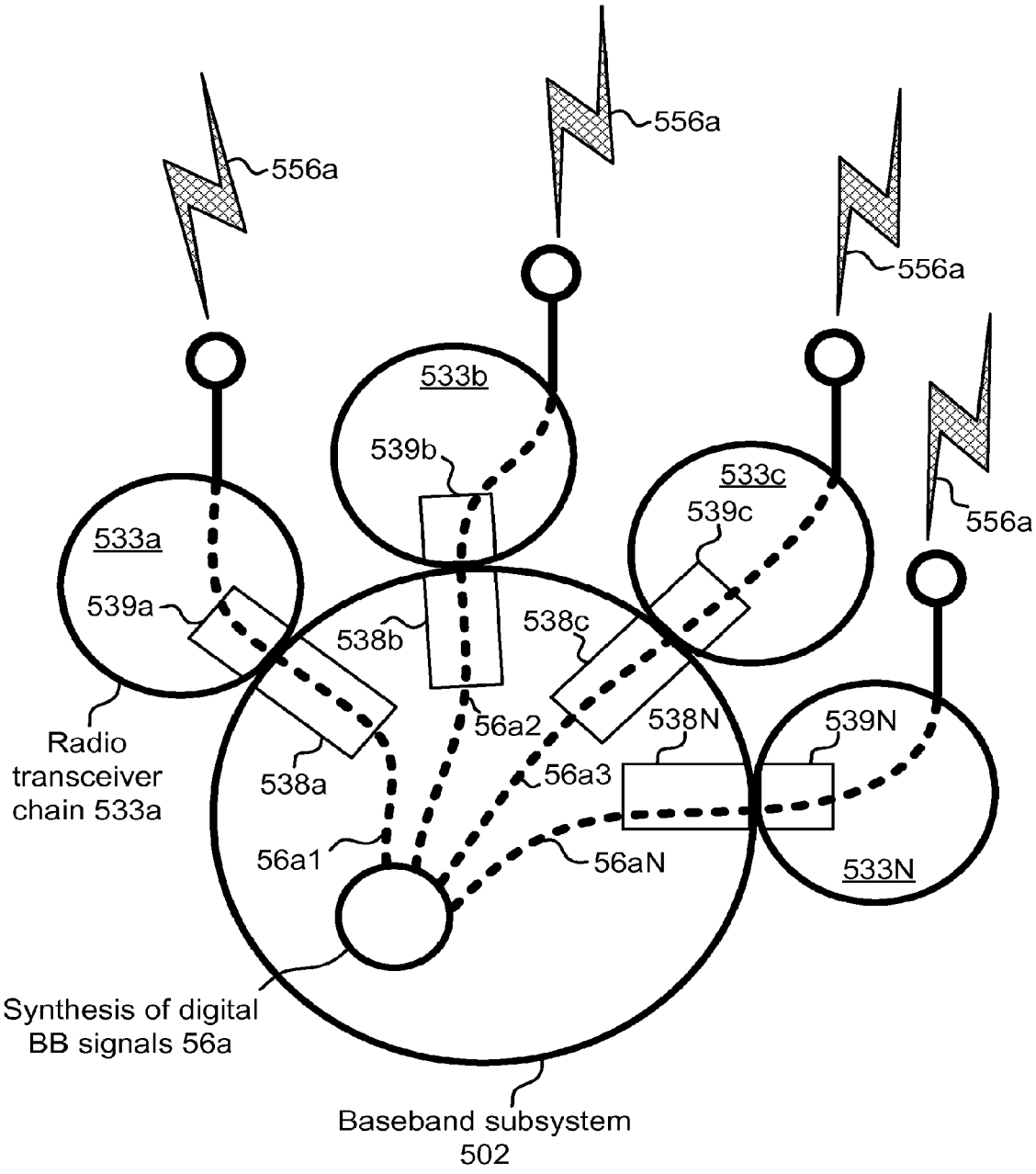
556a
556a
556a
556a
533b
539b
533c
539c
533a
539a
538b
538c
56a2
538N
539N
Radio transceiver chain 533a
538a
56a3
56a1
56aN
533N
Synthesis of digital BB signals 56a
Baseband subsystem 502

FIG. 11

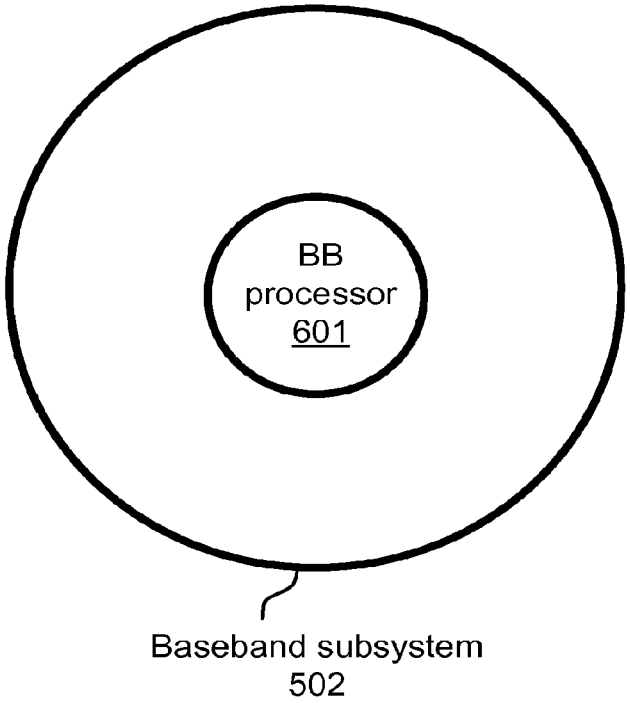
BB
processor
601
Baseband subsystem
502

FIG. 12

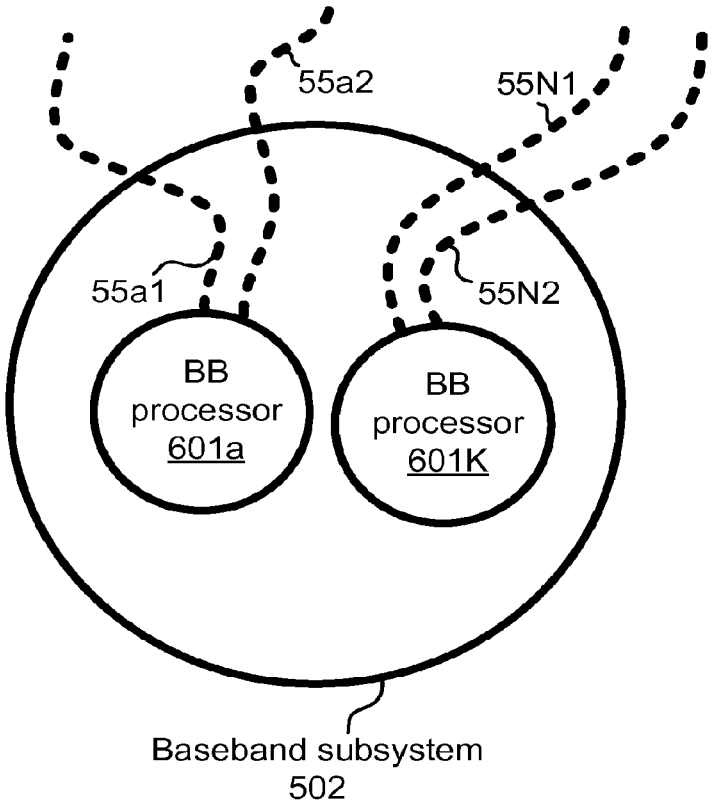
55a2
55N1
55a1
55N2
BB
processor
601a
BB
processor
601K
Baseband subsystem
502

FIG. 13

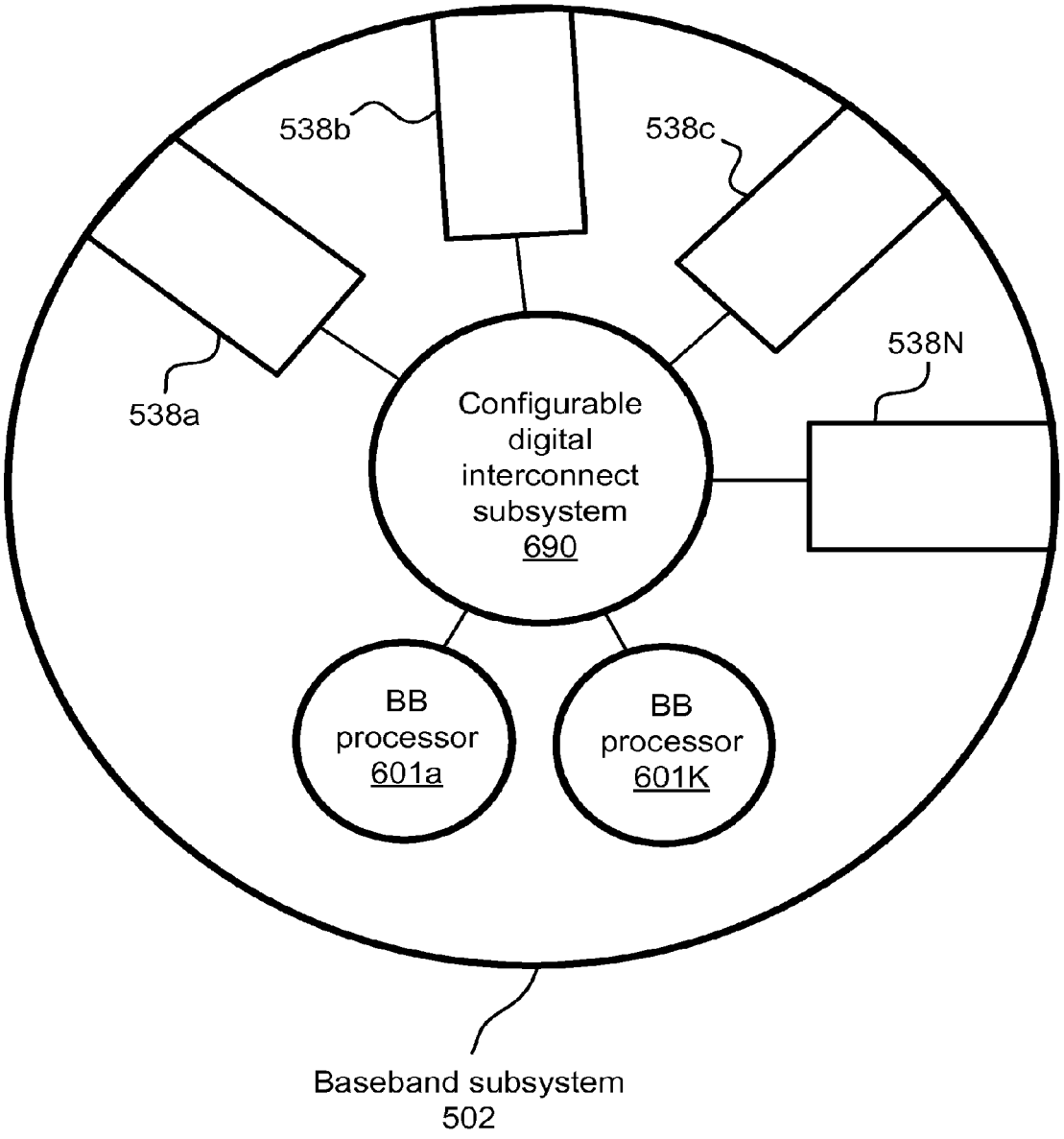
538b
538c
538a
538N
Configurable digital interconnect subsystem 690
BB processor 601a
BB processor 601K
Baseband subsystem 502

FIG. 14

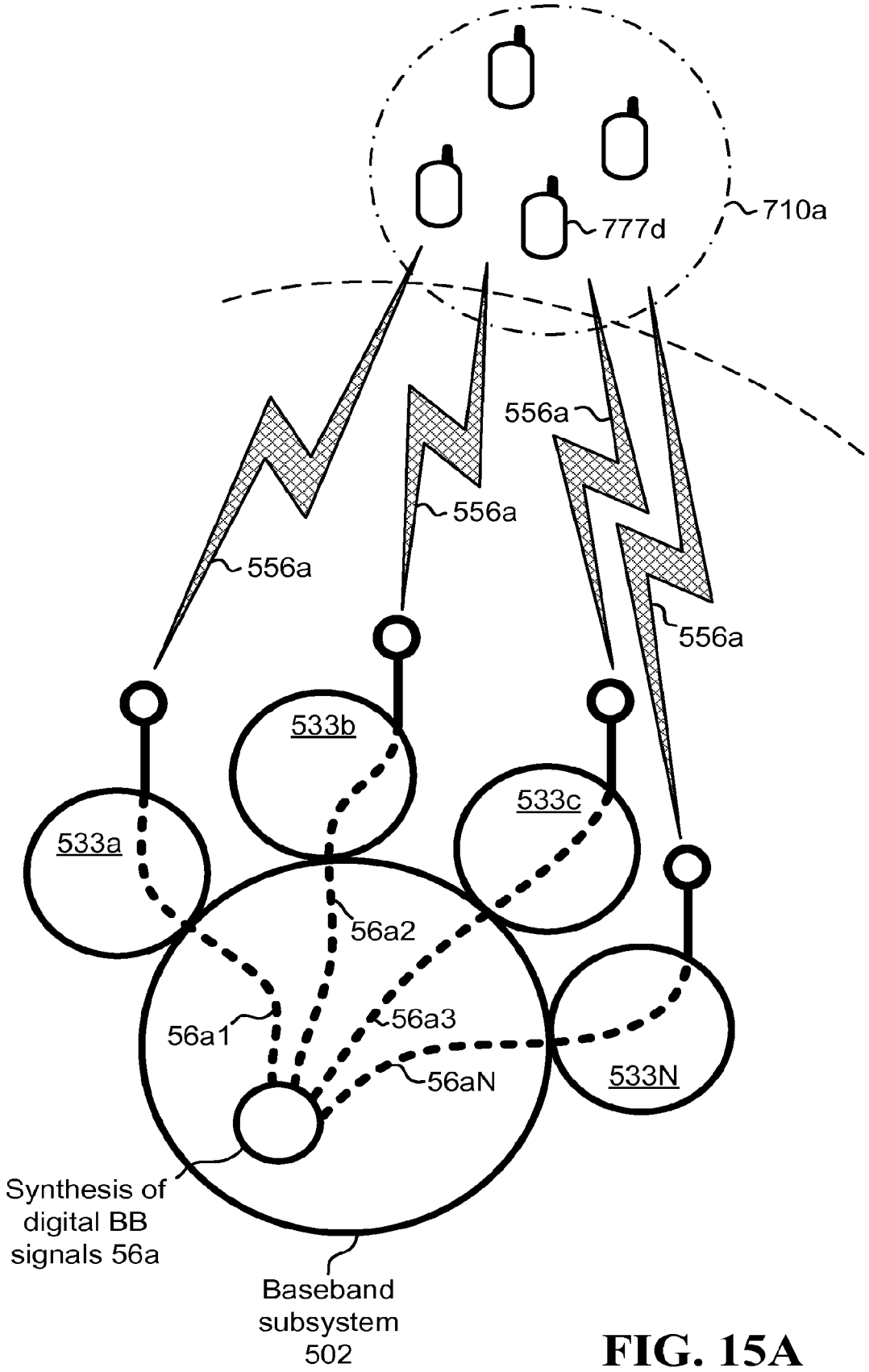
710a
777d
556a
556a
556a
556a
533a
533b
533c
533N
56a1
56a2
56a3
56aN
Synthesis of digital BB signals 56a
Baseband subsystem 502

FIG. 15A

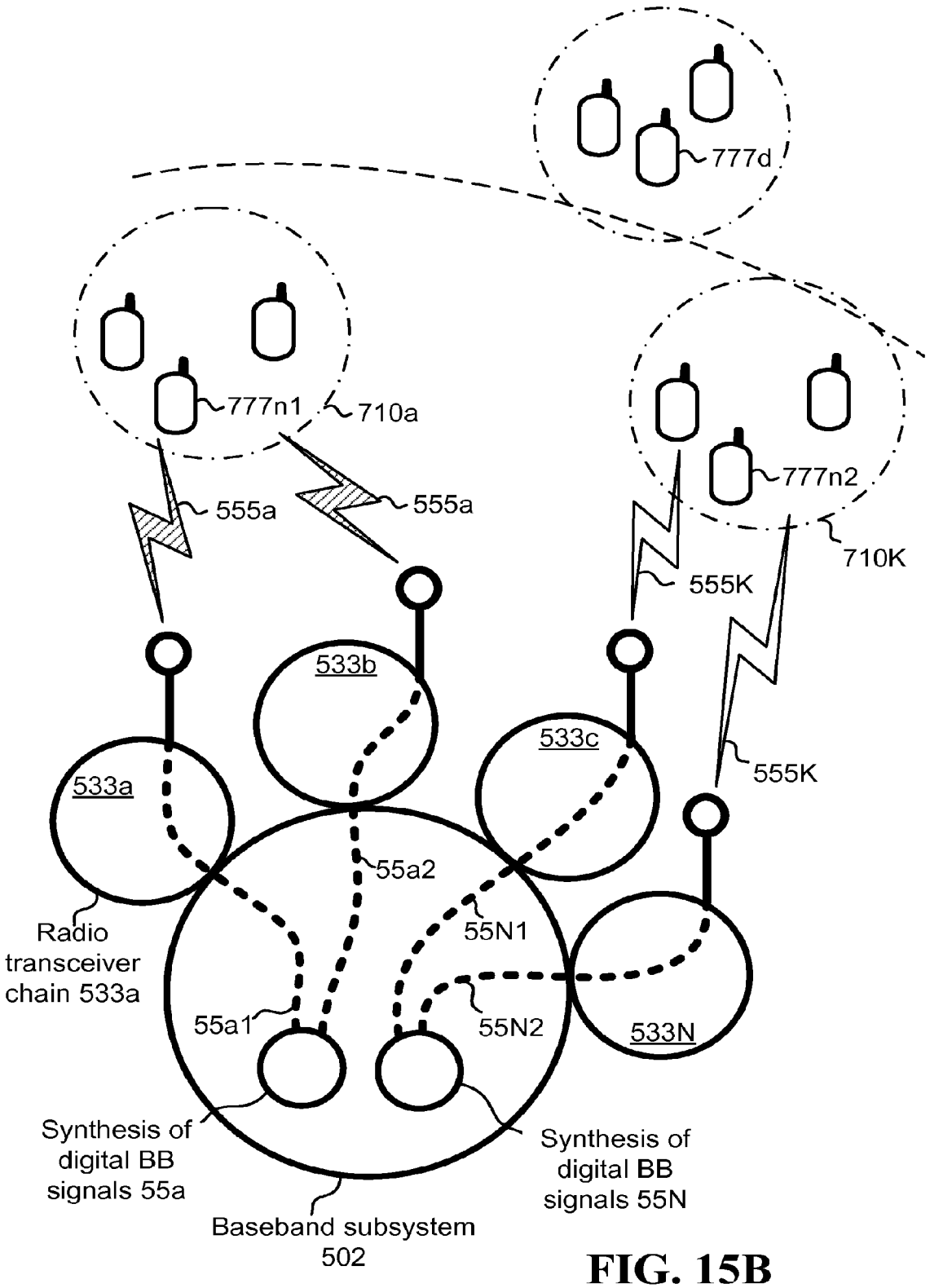
777d
777n1
710a
555a
555a
777n2
710K
555K
555K
533b
533c
533a
55a2
55N1
Radio transceiver chain 533a
55a1
55N2
533N
Synthesis of digital BB signals 55a
Synthesis of digital BB signals 55N
Baseband subsystem 502

FIG. 15B

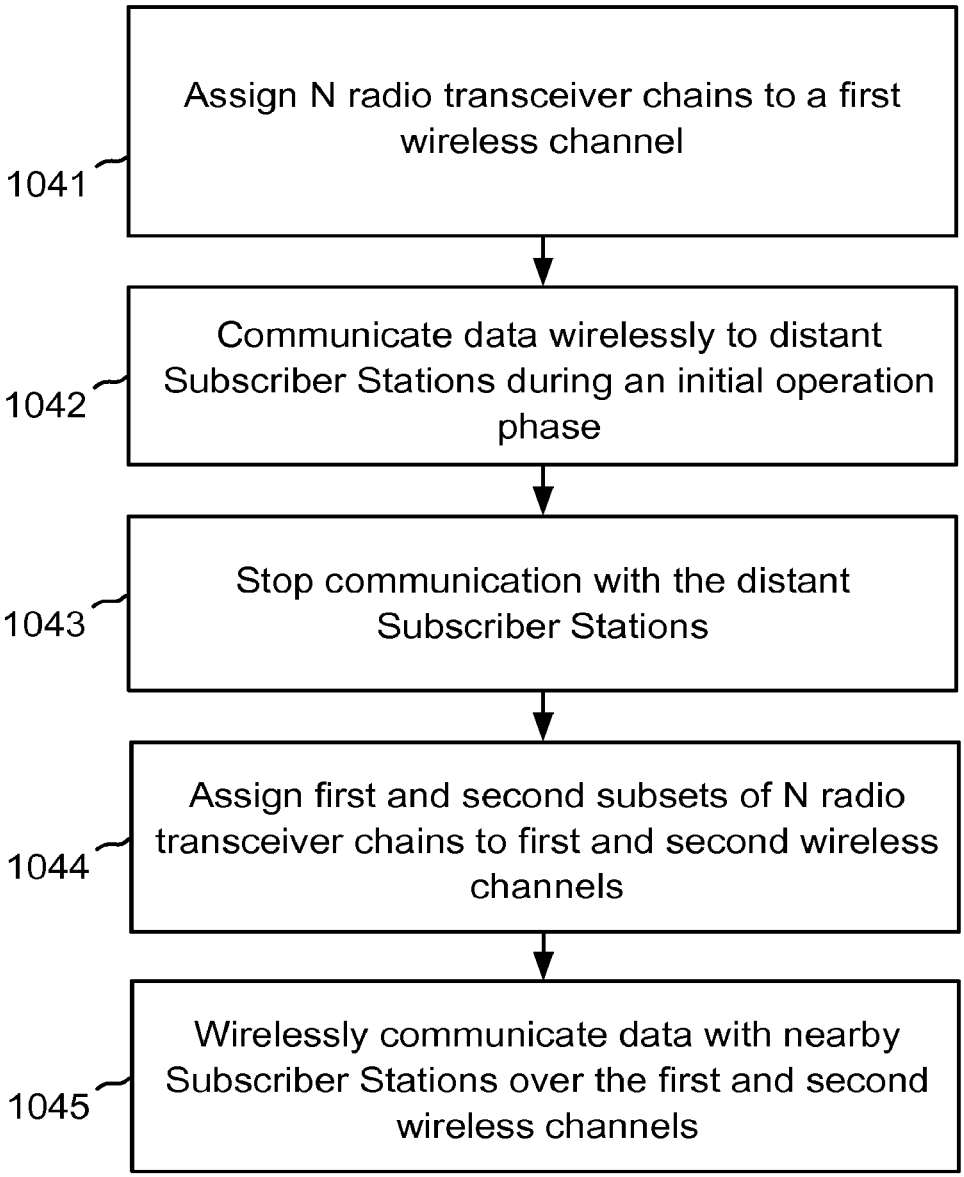
Assign N radio transceiver chains to a first wireless channel
1041
Communicate data wirelessly to distant Subscriber Stations during an initial operation phase
1042
Stop communication with the distant Subscriber Stations
1043
Assign first and second subsets of N radio transceiver chains to first and second wireless channels
1044
Wirelessly communicate data with nearby Subscriber Stations over the first and second wireless channels
1045

FIG. 16

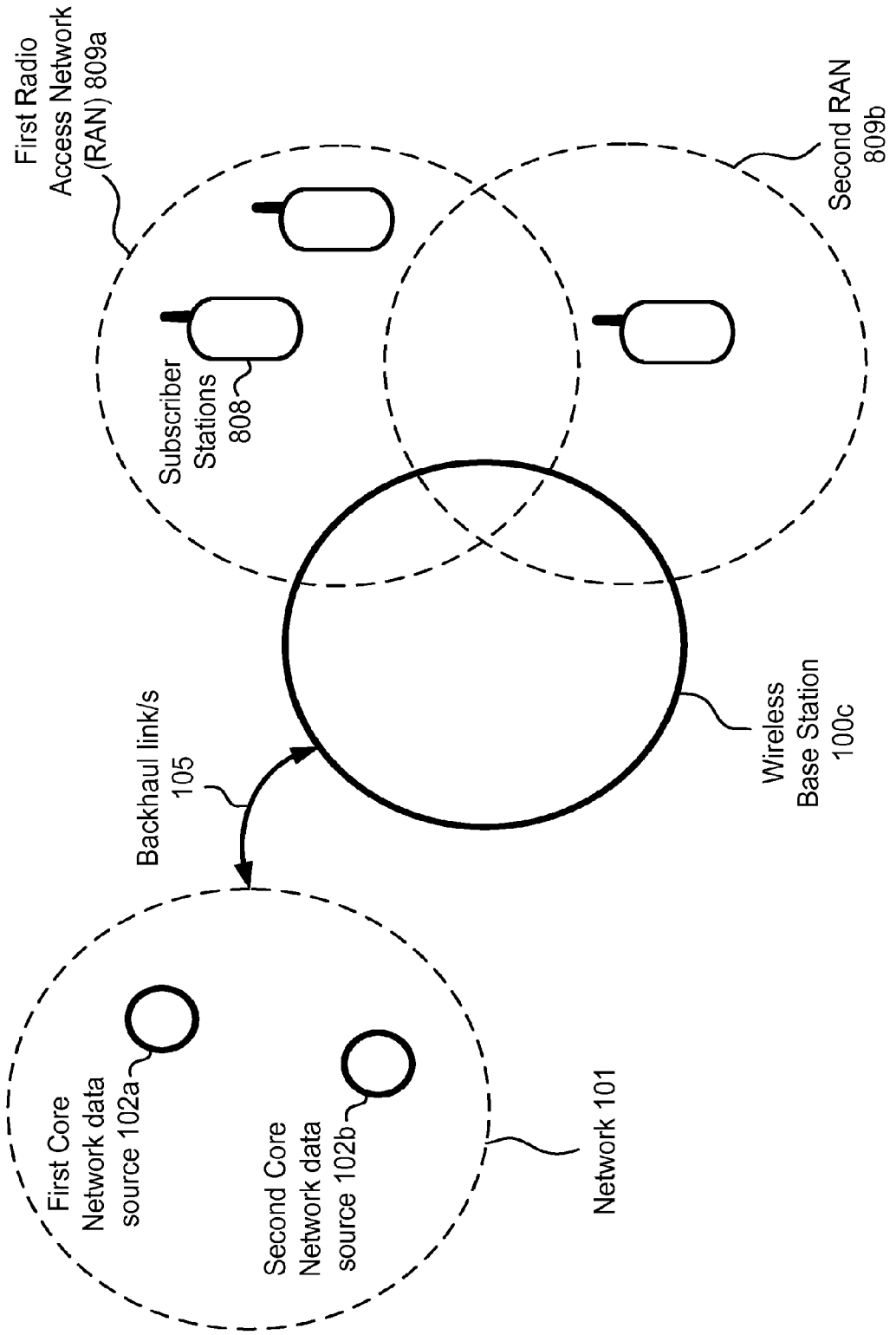
First Radio Access Network (RAN) 809a
Second RAN 809b
Subscriber Stations 808
Backhaul link/s 105
Wireless Base Station 100c
First Core Network data source 102a
Second Core Network data source 102b
Network 101

FIG. 17

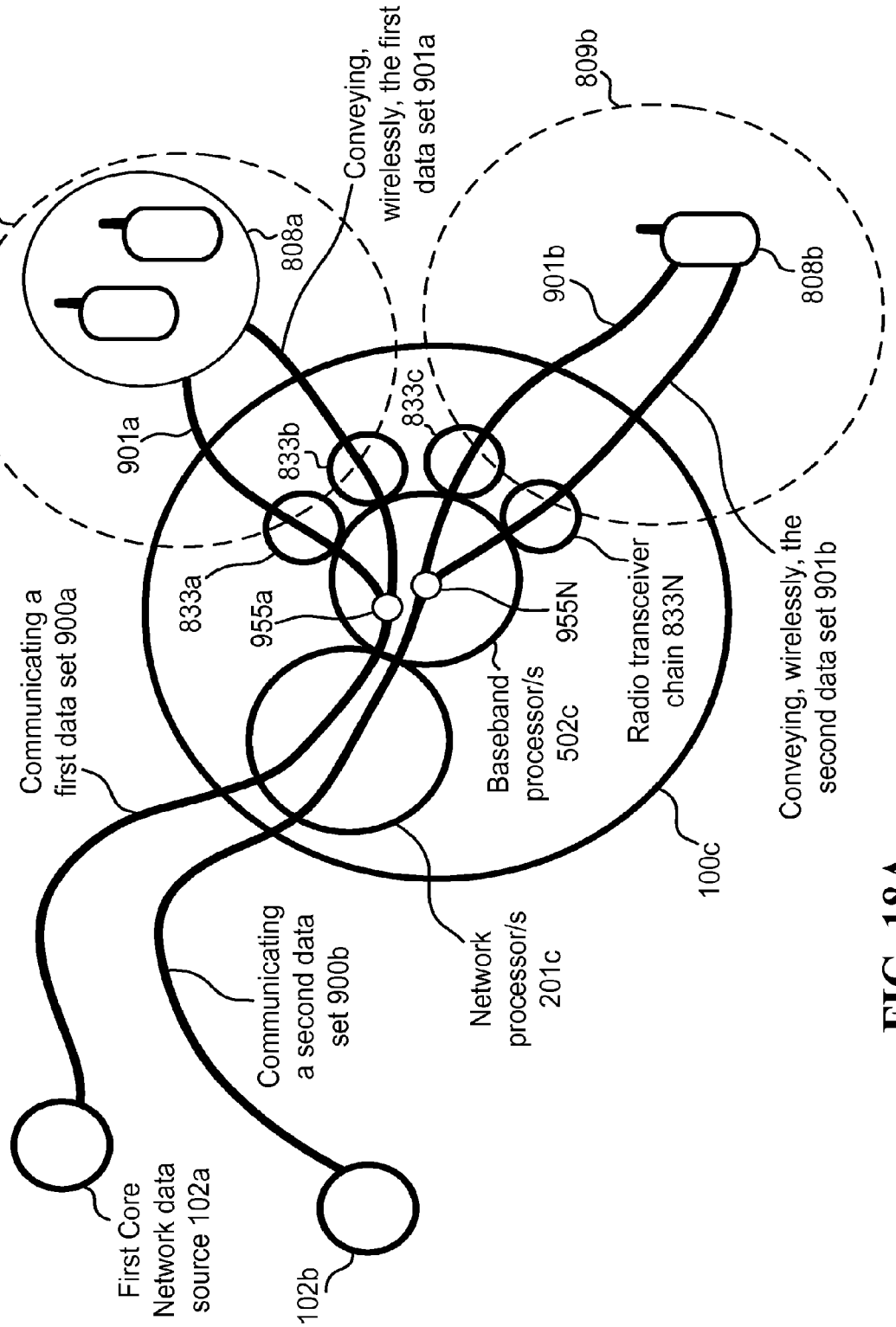
809a
808a
Conveying, wirelessly, the first data set 901a
809b
901a
833b
833c
901b
808b
833a
955a
955N
Communicating a first data set 900a
Baseband processor/s 502c
Radio transceiver chain 833N
Conveying, wirelessly, the second data set 901b
100c
Communicating a second data set 900b
Network processor/s 201c
First Core Network data source 102a
102b

FIG. 18A

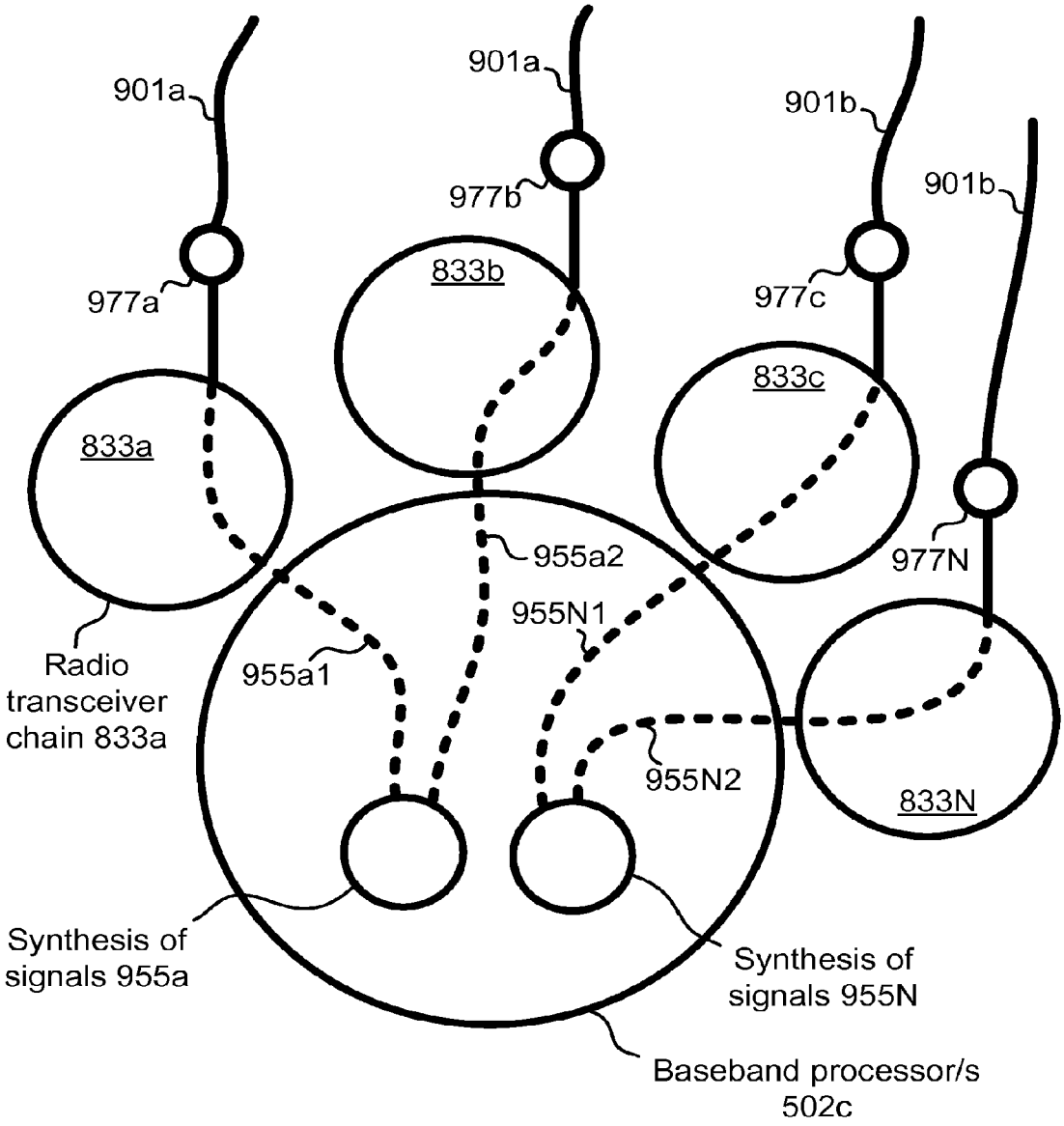
901a
901a
901b
901b
977b
977a
977c
833b
833c
833a
977N
955a2
955N1
955a1
Radio transceiver chain 833a
955N2
833N
Synthesis of signals 955a
Synthesis of signals 955N
Baseband processor/s 502c

FIG. 18B

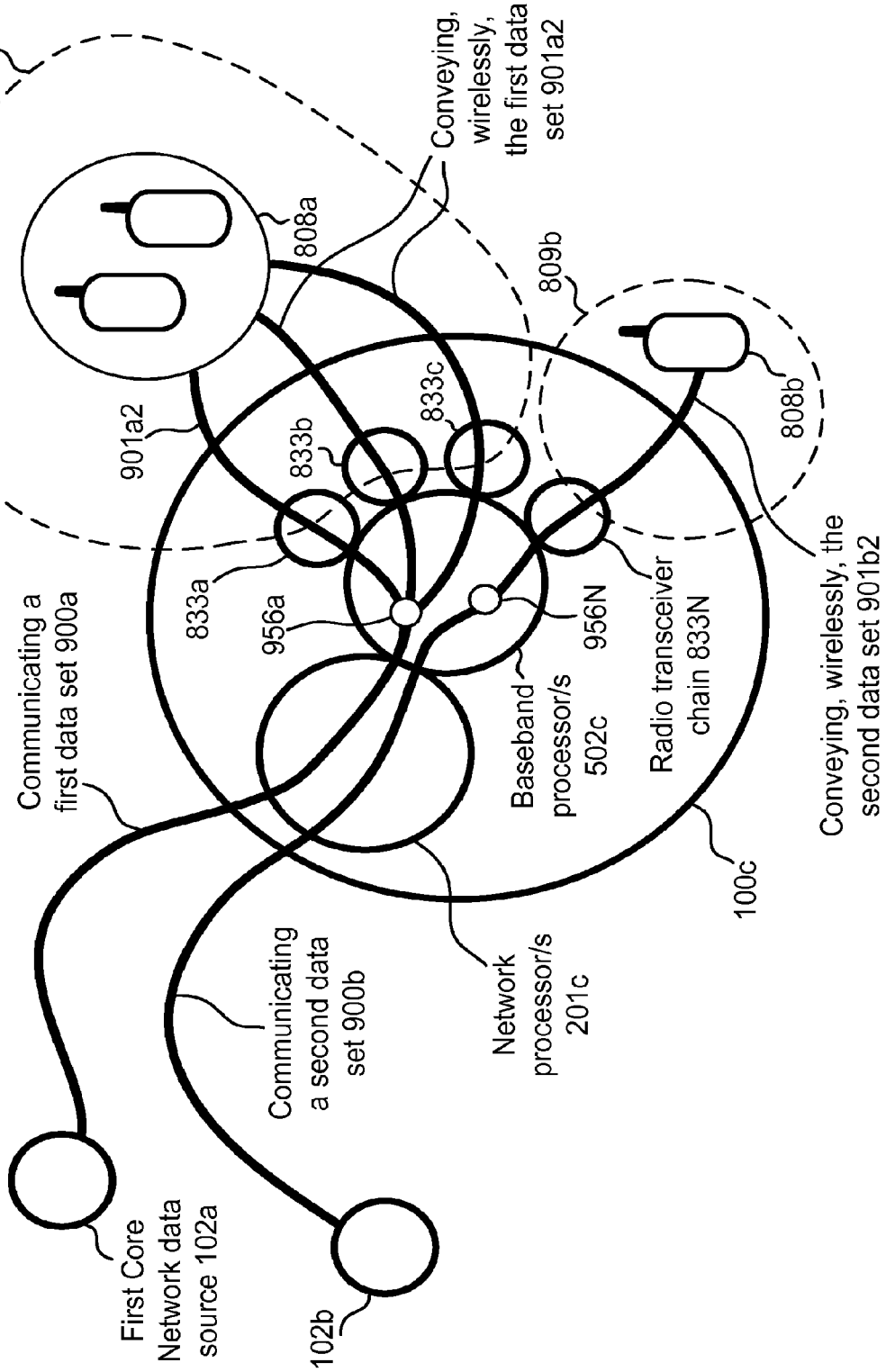
809a
808a
Conveying, wirelessly, the first data set 901a2
809b
901a2
833b
833c
808b
833a
956a
956N
Communicating a first data set 900a
Baseband processor/s 502c
Radio transceiver chain 833N
Conveying, wirelessly, the second data set 901b2
100c
Communicating a second data set 900b
Network processor/s 201c
First Core Network data source 102a
102b

FIG. 19A

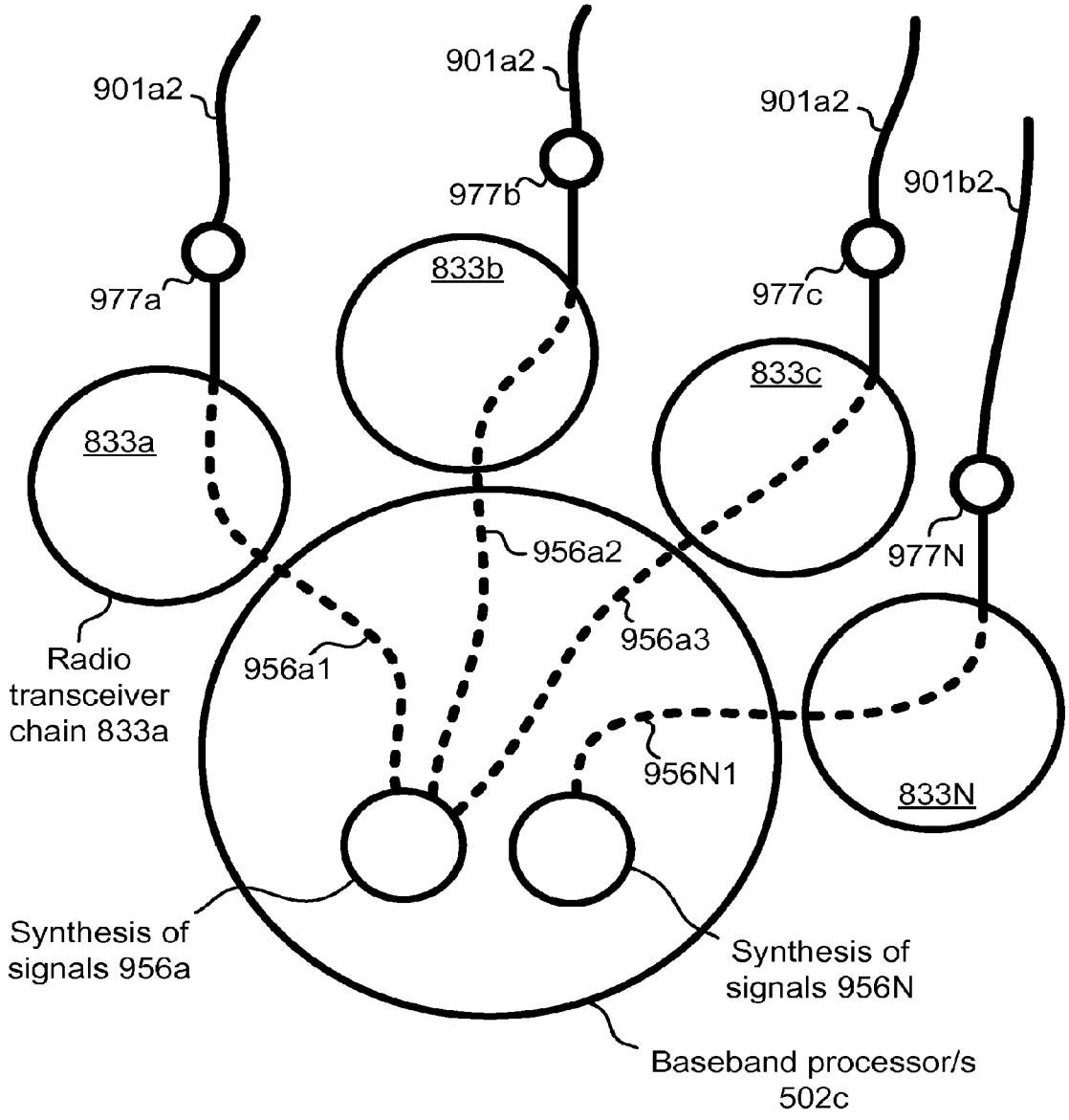
901a2
901a2
901a2
901b2
977b
977a
977c
833b
833c
833a
977N
956a2
956a3
956a1
Radio transceiver chain 833a
956N1
833N
Synthesis of signals 956a
Synthesis of signals 956N
Baseband processor/s 502c

FIG. 19B

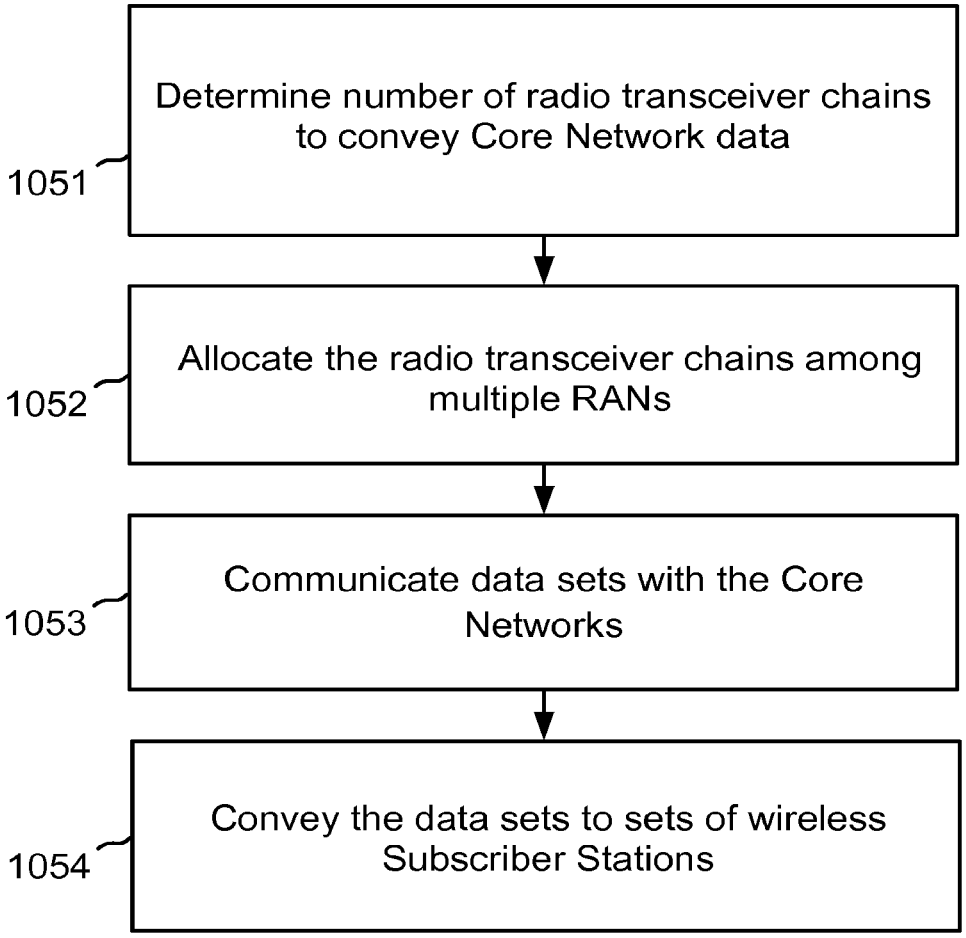
Determine number of radio transceiver chains to convey Core Network data
1051
Allocate the radio transceiver chains among multiple RANs
1052
Communicate data sets with the Core Networks
1053
Convey the data sets to sets of wireless Subscriber Stations
1054

FIG. 20

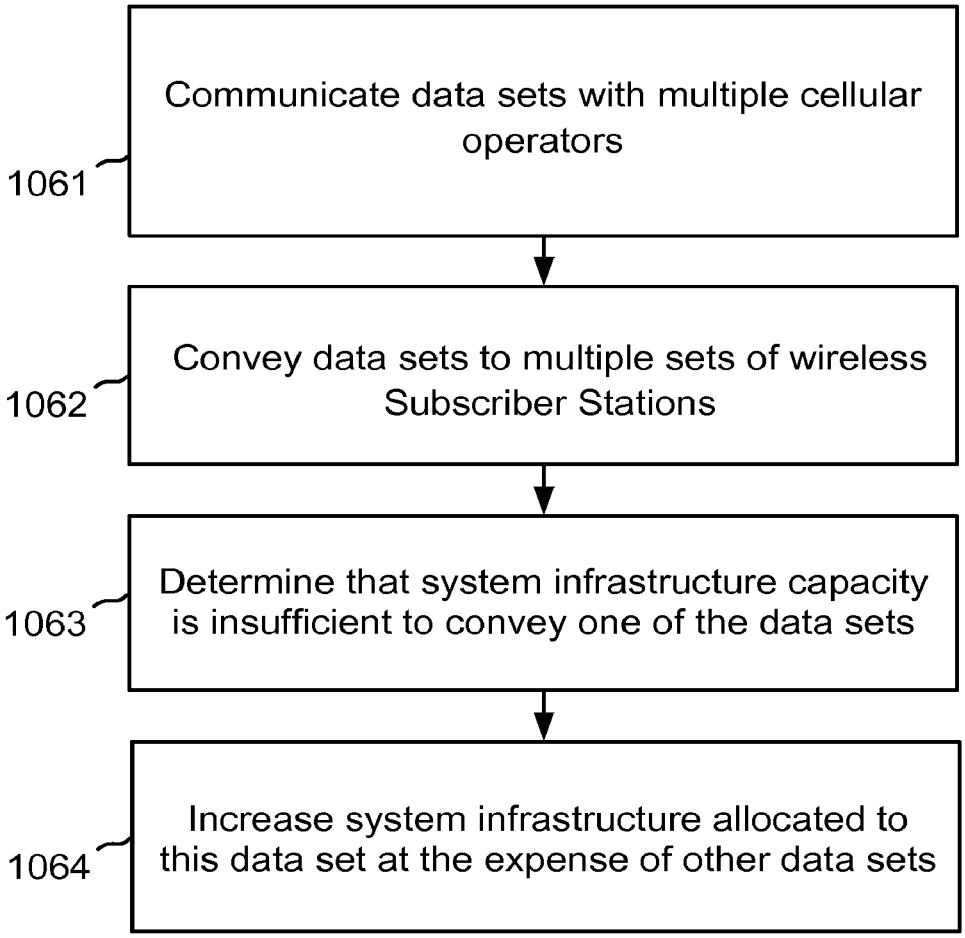
Communicate data sets with multiple cellular operators
1061
Convey data sets to multiple sets of wireless Subscriber Stations
1062
Determine that system infrastructure capacity is insufficient to convey one of the data sets
1063
Increase system infrastructure allocated to this data set at the expense of other data sets
1064

FIG. 21

# ARCHITECTURE, DEVICES AND METHODS FOR SUPPORTING MULTIPLE CHANNELS IN A WIRELESS SYSTEM

## CROSS REFERENCE TO RELATED APPLICATIONS

This application is a continuation of and claims priority to U.S. Application No. 13/235,569, filed Sep. 19, 2011, now U.S. Pat. No. 8,891,464, which is hereby incorporated by reference herein in its entirety.

## BACKGROUND

The recent advent of so-called "smart phones" and other wireless devices has increased wireless system usage for both data and voice services, thereby creating at least two problems in a changing infrastructure landscape. One problem is a secular trend with rising demand for infrastructure in specific geographic areas. This causes a need either to invest in additional infrastructure resources, including frequencies, hardware and software, at significant cost, or simply not to provide certain bit-heavy services in some cases. A second problem is a variation of the first problem. In an area with increasing or heavy demand, the level of demand will fluctuate according to season, time of day, the occurrence of specific events in the area, and due to other factors. If demand is relatively light, but the infrastructure capacity is inflexibly fixed, then there will likely be unused infrastructure capacity. If demand is relatively heavy, there may be insufficient infrastructure capacity to meet the demand.

One natural solution to the first problem, employed in the prior art, is simply to add system capacity. This may be an expensive solution, but given sufficient investment, the first problem might be solved temporarily. However, this solution does not solve, and indeed may exacerbate, the second problem of inflexible infrastructure.

What are needed are a system and a method with scalable and variable capacity to help alleviate both problems. This system and method would achieve resource flexibility to deal with the second problem, but at the same time achieve long-term increase of system capacity to deal with the first problem.

## BRIEF SUMMARY

One embodiment is a wireless Base Station (BS) system designed to assign dynamically a plurality of radio transceiver chains among a varying number of wireless channels. Such a system would include a Baseband (BB) subsystem comprising N digital ports, operative to synthesize N digital Base-Band (BB) signals associated with K wireless channels, wherein N is equal to at least 2, K is equal to at most N, and K is equal to at least 1. Such a system would also include N radio transceiver chains, each chain connecting to one of the N digital ports of the BB subsystem via a two-way Analog-Digital interface. In one embodiment, the system sets dynamically K according to a first criterion wherein K is a number between 1 and N, then assigns dynamically the N radio transceiver chains among the K wireless channels according to a second criterion such that each radio transceiver is assigned to only one of the wireless channels. The BB subsystem then synthesizes the N digital BB signals associated with the K wireless channels, and inputs the N digital BB signals to the N radio transceiver chains via the corresponding N digital ports and the corresponding Analog-Digital interfaces, thereby transmitting the K wireless channels via the N radio transceiver chains.

One embodiment is a method for transitioning from a range-extension mode to an enhanced-capacity mode in a wireless Base Station (BS). The steps of such a method are (1) a wireless BS assigning N radio transceiver chains to a first wireless channel associated with a first frequency range, (2) the wireless BS communicating data wirelessly during an initial operation phase with distant Subscribed Stations, over the first wireless channel and via the N radio transceiver chains, thereby utilizing the aggregated transmission power and the aggregated reception capability of the N radio transceiver chains to reach the distant Subscribed Stations, (3) the wireless BS stopping communication with the distant Subscriber Stations at the end of the initial operation phase, and (4) the wireless BS assigning mutually exclusive first and second subsets of N radio transceiver chains to, respectively, a first group of wireless channels associated with a first frequency range and a second group of wireless channels associated with a second frequency range.



## BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the present invention are herein described, by way of example only, with reference to the accompanying drawings. With specific reference now to the drawings, it is stressed that the particulars shown are by way of example and for purposes of illustrative discussion of embodiments of the present invention only, and are presented in order to provide what is believed to be the most useful and readily understood description of the principles and conceptual aspects of embodiments of the present invention. In this regard, no attempt is made to show structural details of embodiments in more detail than is necessary for a fundamental understanding of the invention. In the drawings:

FIG. **1**A illustrates one embodiment of components comprising a system of a wireless Base Station (BS) communicating with multiple Radio Access Networks (RANs);

FIG. **1**B illustrates one embodiment of components comprising a system of a wireless Base Station (BS) communicating with multiple Radio Access Networks (RANs), in which there is illustrated the allocation of spectrum to the RANs, components of wireless BS, and communication paths between the wireless BS and the Core Networks;

FIG. **1**C illustrates one embodiment a possible allocation of wireless Access Spectrum to two Radio Access Networks (RANs);

FIG. **2** illustrates one embodiment of components comprising a system of a wireless Base Station (BS) communicating with multiple Radio Access Networks (RANs), in which two RANs are sharing one radio transceiver chain;

FIG. **3** illustrates one embodiment of components comprising a system of a wireless Base Station (BS) communicating with multiple Radio Access Networks (RANs), in which each of two RANs has its own radio transceiver chain, and the RANs share other resources within the wireless BS;

FIG. **4** illustrates one embodiment of a Baseband Processor included as part of a system of a wireless Base Station (BS) communicating with multiple Radio Access Networks (RANs), in which two RANs are sharing one radio transceiver chain;

FIG. **5** illustrates one embodiment of a Baseband Processor included as part of a system of a wireless Base Station (BS) communicating with multiple Radio Access Networks (RANs), in which each of two RANs has its own radio transceiver chain, and the RANs share other resources within the wireless BS;

FIG. **6**A illustrates one embodiment of the functioning of a Baseband Processor in a system comprising a wireless Base Station (BS) communicating with multiple Radio Access Networks (RANs), in which two RANs are sharing one radio transceiver chain;

FIG. **6**B illustrates one embodiment of a possible allocation of wireless Access Spectrum to two Radio Access Networks (RANs), in which the allocation can be changed dynamically;

FIG. **7** illustrates one embodiment of components comprising a system of a wireless Base Station (BS) communicating with multiple Radio Access Networks (RANs), in which is also illustrated one possible configuration of a communication link from multiple Core Networks through a wireless Base Station to multiple RANs and then to multiple sets of wireless Subscriber Stations;

FIG. **8** illustrates one embodiment of the elements of a method for dynamically generating a plurality of Radio Access Networks (RAN) by a single wireless Station (BS);

FIG. **9** illustrates one embodiment of the elements of a method for servicing multiple Operators via a single wireless Base Station (BS) utilizing dynamic allocation of spectrum;

FIG. **10**A illustrates one embodiment of components comprising a system for assigning dynamically a plurality of transceiver chains among a varying number of wireless channels;

FIG. **10**B illustrates one embodiment of a digital interface of a Baseband processor subsystem within a system for assigning dynamically a plurality of transceiver chains among a varying number of wireless channels;

FIG. **10**C illustrates one embodiment of multiple signal paths in a Baseband processor subsystem within a system including two distinct radio channels;

FIG. **11** illustrates one embodiment of multiple signal paths in Baseband processor subsystem within a system including one radio channel;

FIG. **12** illustrates one embodiment of a Baseband processor subsystem;

FIG. **13** illustrates one embodiment of a Baseband processor subsystem including at least two Baseband processors;

FIG. **14** illustrates one embodiment of a Baseband processor subsystem including at least two Baseband processors, in which a configurable digital interconnect subsystem connects with the Baseband processors;

FIG. **15**A illustrates one embodiment of components comprising a system for assigning dynamically a plurality of transceiver chains among a varying number of wireless channels, in which the system appears in a range-extension mode;

FIG. **15**B illustrates one embodiment of components comprising a system for assigning dynamically a plurality of transceiver chains among a varying number of wireless channels, in which the system appears in an enhanced-capacity mode;

FIG. **16** illustrates one embodiment of elements of a method for transitioning from a range extension mode to an enhanced capacity mode in a wireless Base Station;

FIG. **17** illustrates one embodiment of components comprising a system for direct communication between multiple Core Networks and a wireless Base Station (BS), and between the wireless BS and multiple Radio Access Networks (RANs);

FIG. **18**A illustrates one embodiment of components of a system with the potential to dynamically allocate a pool of at least three radio transceiver chains between first and second RANs;

FIG. **18**B illustrates one embodiment of a Baseband Processor which has allocated two signals to one wireless channel and two other signals to a second wireless channel;

FIG. **19**A illustrates one embodiment of components of a system in which a pool of at least three radio transceiver chains has been dynamically reallocated between first and second RANs;

FIG. **19**B illustrates one embodiment of a Baseband processor which has allocated three signals to one wireless channel and one other signals to a second wireless channel;

FIG. **20** illustrates one embodiment of the elements of a method for dynamically generating a plurality of Radio Access Networks (RANs) by a single wireless Base Station (BS); and

FIG. **21** illustrates one embodiment of the elements of a method for servicing multiple Operators via a single wireless Base Station (BS) utilizing dynamic allocation of radio transceiver chains.

## DETAILED DESCRIPTION

A number of terms are used in the presentation of embodiments, among which are the following:

An "Analog-Digital Interface", also called a "Two-Way Analog-Digital Interface", is a converter between two components of a system that converts analog signals to digital signals, or digital signals to analog signals, depending on the need. One example of an Analog-Digital Interface is an interface between a Baseband subsystem and radio transceiver chain. Each of the components listed may have additional sub-components, some of which are listed in the embodiments described herein. Different configurations of the components are described in some of the embodiments. Different communication paths and processes between components are described in some of the embodiments. The components, sub-components, configurations, and communication paths and processes, presented herein, are intended to present only some of the embodiments, and are illustrative only.

A "wireless Base Station", or "Base Station", is a collection of hardware and software that communicates to Subscriber Stations over the RAN, using any of a variety of standardized or proprietary protocols, in TDD or FDD mode, and on one or more channels of wireless Access Spectrum. If a Base Station can operate on multiple radio channels of spectrum that are considered to be relatively closely separated from each other (or even adjacent to one another), the Base Station is referred to as a "multi-carrier Base Station". If a multi-carrier Base Station can operate on widely separated frequencies then it may additionally be referred to as a "multi-band Base Station". A "multi-mode Base Station" is a Base Station that supports multiple wireless protocols. Non-limiting examples of such wireless protocols include LTE and WiFi. The wireless Base Station generates the RAN.

By industry convention, and also herein, "Base Station" includes not just the hardware processing device in which radio processing and baseband processing occurs, but also the radio transceiver chain connected to such hardware processing device, and the antennas in physical connection with the radio transceiver chain. In some embodiments, each such hardware processing device is connected to one radio transceiver chain, and each radio transceiver chain is connected to one antenna. However, it is possible to have multiple antennas connected to one radio transceiver chain. It is also possible to have one antenna in connection with multiple radio transceiver chains, in which case there would be a power combiner that combines the signals from the radio transceiver chains into the one antenna. It is also possible to split one radio

transceiver chain to multiple hardware processing devices, so that the multiple hardware devices feed signals to the radio transceiver chain. It is also possible to have one hardware processing device connected to multiple radio transceiver chains. All of the possible configurations discussed herein come within the term "Base Station".

A "Baseband Processor" (BP) is a device, typically a chip or a part of a chip in a Base Station, that manages and performs signal processing and radio control functions. Modulation and demodulation of communication signals are typically performed by a BP. A BP is a component of a wireless Base Station, and also typically appears in advanced consumer wireless equipment, although the configuration of the BP device will vary depending on many factors, including, among others, whether it will function in the wireless BS or in the consumer wireless device.

A "Core Network" is a part of a mobile communication network that provides various services to Subscriber Stations who are connected to the Core Network via a RAN. An Operator's Core Network is the aggregation point of data to and from multiple Base Stations, and typically includes equipment and software for subscriber authentication, monitoring, metering, billing, control, and overall administration of the network. A Base Station communicates to the Core Network over the Base Station's "backhaul interface", which may be either wired or wireless.

A "Gateway device" is a device through which passes all traffic to and from a set of Base Stations. Most Operators organize their networks with one or more Gateway devices, although strictly speaking, this is not essential. Communication between a Base Station and a Gateway is generally governed by a standard or proprietary protocol, and will usually vary to some degree among Operators, even when all the Operators are using a technical standards-based approach. This protocol, whether standard for multiple Operators or proprietary to one Operator, is almost always carried "in-band". "In-band" means that the communication protocol between a Base Station and a Gateway is logically multiplexed with the data itself on the Base Station's backhaul interface.

Some Base Stations also communicate directly with one another, rather than through a Gateway. One typical reason for such communication is to exchange time-sensitive information related to inter-Base Station subscriber handover operations. Another typical reason for such communication is to help implement or improve load-balancing between Base Stations. Inter-Base Station communication, for whatever reason it is implemented, is typically governed by standard or proprietary protocols, and such protocols, even if standard, will usually vary among Operators and even among manufacturers of infrastructure equipment.

A "network Tunnel" or "Tunnel" is a network communications channel between two networks. It is used to transport another network protocol by encapsulation of the protocol packets. Tunnels are often used for connecting two disjoint networks that lack a native routing path to each other, via an underlying routable protocol across an intermediate transport network. In IP tunneling, every IP packet, including addressing information of its source and destination IP networks, is encapsulated within another packet format native to the transit network. At the borders between the source network and the transit network, as well as the transit network and the destination network, Gateways are used that establish the end-points of the IP tunnel across the transit network. IP Tunnels are logical, rather than physical, interfaces. Examples of network Tunnels are IP Tunnels and Generic Routing Encapsulation (GRE).

An "Operator" is a company or other entity that provides wireless services to subscribers. An Operator may operate regionally, nation-wide, or even globally. An Operator may utilize either Licensed or Unlicensed spectrum, or a combination of both. Each portion of an Operator's spectrum may be deployed as half-duplex, time division duplex (TDD), full-duplex, or frequency division duplex (FDD). An Operator's spectral allocation may be uniform across its service area, or may vary from region to region. If multiple Operators function in different and non-overlapping geographic regions, the same frequency range may be allocated to different Operators in different regions.

A "Radio Access Network" (RAN) is a part of a mobile communication system that implements radio access technology. In a wireless communication system, the RAN sits between the Subscriber Station and the Core Network. The RAN is generated by the wireless BS.

"Roaming" is a situation where a Subscriber Station assigned to a particular Operator, encounters a wireless network belong to a different Operator, where frequency encountered by the Subscriber Station is supported by the different Operator, and the Subscriber Station receives service from that different Operator.

"Subscriber Stations" are wireless communication devices used by customers of an Operator. Such Subscriber Stations are typically, but not necessarily and not always, locked to all or a subset of the radio frequencies licensed to that Operator. Some possible non-limiting categories of Subscriber Stations include handsets, dongles, customer premises equipment (CPE) for wireless communication, and hot spot equipment for wireless communication. Non-limiting examples of handsets include cellular telephones of all kinds, PDAs, wireless data devices, pages, and other consumer radio equipment.

"Wireless Access Spectrum" is the radio spectrum on which a RAN operates, and hence the radio spectrum is utilized by both Subscriber Stations to access the wireless Base Station and the wireless Base Station to communicate with Subscriber Stations.

There is a need for a practical way by which various Operators may collaborate and share infrastructure equipment and other resources. The sharing of resources by multiple Operators can be advantageous to all parties. Devices, systems, and methods are presented herein for a wireless Base Station (BS) capable of substantially simultaneously providing service to subscribers of multiple Operators. Depending upon the particular deployment requirements or equipment capabilities, each Operator may be operating on the same or different frequencies. If frequencies are different, they may be adjacent, closely separated, or widely separated. The wireless BS will distinguish and logically separate and route the traffic between each Subscriber Station and the Core Network providing service to that Subscriber Station. The wireless BS may support different logical or different physical interfaces between the wireless BS and each Operator.

Where limited wireless or processing resources are shared among the Operators, load balancing techniques and methods may be deployed to govern the allocation of these resources. Non-limiting examples of shared resources include Subscriber Stations of multiple Operators sharing the same frequency, Operators sharing one or more radio chains, shared antennas, shared transmit power, shared backhaul, and one or more processors which process communication for multiple Operators. For these and other cases of shared resource utilization, load balancing techniques and methods may apply within a single Base Station, or among a group of Base Stations on a network. Such load balancing techniques and methods may be distributed, or controlled centrally, or have

dynamically shifting control as the needs change. Considerations in the selection and deployment of load balancing techniques may be technical or financial or both. Such considerations may affect the load balancing algorithms and decisions. As an example of a consideration that is both technical and financial, one Operator may be heavily loaded at a particular time while another Operator may be lightly loaded at the same time. By agreement between the Operators, the heavily loaded Operator may off-load capacity by utilizing resources normally allocated to the lightly loaded Operator. An agreement like this would typically include financial compensation from the heavily loaded Operator to the lightly loaded Operator, and such compensation may be cost per usage, fixed cost per period or by event, variable cost depending on such factors as time and relative loading, or on any other basis agreed upon by the Operators.

Many possible embodiments of a multi-Operator BS may be imagined. A very few non-limiting examples include the following:

(1) According to one multi-Operator BS scenario, at least Subscriber Devices of one Operator in the geographic region of interest may not have the capability to roam onto another Operator's licensed spectrum. This could be because such Subscriber Devices of a first Operator do not contain the appropriate frequency support to function on the frequency of the second Operator, or because such Subscriber Devices are locked onto the first Operator's network, or because such Subscriber Devices are locked out of the other Operator's network.

In one embodiment, this problem may be handled by either a multi-carrier or multi-band Base Station, with one or more distinct carriers allocated to each Operator. The relative amounts of spectrum allocated among the Operators could impact the allocation of carriers among the Operators. In this embodiment, the Base Station may support multiple logical core-network interfaces, one for each Operator, and the interfaces may be either standardized or customized for each different Operator. Communication may be multiplexed onto the same physical backhaul interface, with each message or even each packet labeled with unique routing information to connect the message or packet to its corresponding core network gateway. However, and alternatively, each logical interface may utilize different physical interfaces.

In this embodiment, load balancing of shared Base Station resources between Operators may apply to any or all of antennas, transmit power, backhaul resources, and processing power.

(2) According to a second multi-Operator BS scenario, at least some subscriber devices of a first Operator in the geographic region of interest do have the capability to roam onto another Operator's licensed spectrum.

For this case, in one embodiment such roaming may be handled by either a multi-carrier or a multi-band Base Station, depending at least in part upon the specific spectrum allocations to the Operators. A Subscriber Station may, by default, connect to its own Operator's spectrum, in which case communication will be effected as explained in scenario (1) above. However, in the event that the Operator's network is heavily loaded, prior art architecture does not allow the Base Station to direct the subscriber to a more lightly loaded Operator's spectrum. In one embodiment, instead of the typical prior art roaming situation, by which a local Operator's network handles the session and later bills the subscriber's Operator per pre-agreement, the Base Station will support multiple logical Core Network interfaces, one such interface for each Operator, and the traffic from the redirected subscriber will be routed to its own Operator's core interface. (Such interface may be logical or physical, or dynamically shifting between logical and physical.) The Base Station, in combination with relevant Core Network elements, can keep track of this shared usage so that the proper financial compensation may be made between Operators.

In this embodiment, load balancing of shared Base Station resources between Operators may apply to spectrum, antennas, transmit power, backhaul resources, processing power, or any of the other elements previously identified as possible shared resources.

(3) According to a third multi-Operator BS scenario, the Base Station and at least some Subscriber Stations in a geographic region of interest, support one or more ranges of unlicensed spectrum or protocols. Various non-limiting examples of an unlicensed protocol are Bluetooth, WiFi, and WiMAX, but there are many such examples of technologies. Often, but not exclusively, such technologies may operate at relatively low power, or may operate in one of the non-licensed bands such as 915 MHz, 2.45 Gz, or 5.8 GHz. This third scenario can occur in combination with either scenario (1) or scenario (2), above.

In one embodiment of a scenario with unlicensed spectrum or protocols, usage on unlicensed spectrum is handled by either a multi-carrier Base Station or multi-band Base Station (depending upon the specific spectrum allocations of the Operators). If multiple protocols are involved, in which a second Operator employs a protocol not used by a first Operator, a multi-mode Base Station may support the different protocols.

In this third scenario of unlicensed spectrum or protocols, licensed operation is handled as in the case of either scenarios (1) or (2) above. At the same time, unlicensed spectrum may be budgeted or simply shared among the participating Operators, or the unlicensed spectrum may be used as a resource that is allocated and charged for by the owner of the Base Station. The owner of the Base Station may be one of the Operators, or may be a separate party. In any event, traffic allocated to unlicensed spectrum supported by a Base Station will again be routed to and from the Operator's Core Network. Such routing may be logical or physical or dynamically changing between logical and physical.

The general architecture for some of the embodiments described herein call for a number of components, including: (1) Subscriber Stations, (2) RANs, (3) antenna and radio chains, the latter including power amplifiers, low noise amplifiers, and one or more transceivers. Each radio chain may operate on the same channel (single-carrier capability), different but closely separated channels (multi-carrier capability), or widely separated channels (multi-band capability), (4) a Baseband subsystem, (5) a network processor that may implement, among other things, an array of logical core network interfaces, each of which multiplex into one or more physical backhaul interfaces, (6) backhaul links, and (7) core Networks.

Each of the components listed may have additional subcomponents, some of which are listed in the embodiments described herein. Different configurations of the components are described in some of the embodiments. Different communication paths and processes between components are described in some of the embodiments. The components, sub-components, configurations, and communication paths and processes, presented herein, are intended to present only some of the embodiments, and are illustrative only.

FIG. **1**A illustrates one embodiment of components in a system. In FIG. **1**A, there is a wireless Base Station (BS) **100**, which is connected by one or more Backhaul links **105** to an IP Network **101**. Said IP Network includes two or more

sources of data. Here, the sources are data that come from a first Core Network, First Core Network data source **102***a*, and from a second Core Network, Second Core Network data source **102***b*. The wireless BS **100** also generates two or more Random Access Networks (RANs), here First RAN **109***a* and Second RAN **109***b*. Each RAN network communicates with one or more Subscriber Stations. In FIG. **1**A, Subscriber Stations **108** are communicatively connected to First RAN **109***a*.

FIG. **1**B illustrates one embodiment of components in a system. The wireless BS **100** includes at least two major components, which are one or more Network processors **201** that communicate with IP Network **101** via the physical Backhaul links **105**. The Backhaul links **105** are physical links, which may be microwave, cable, or any other communication medium. Backhaul links **105** provide a path for the logical links, which are the network Tunnels connecting Core Network data sources with the Network processors **102**. In FIG. **1**B, First network Tunnel **105***a* communicatively connects First Core Network data source **102***a* with Network processors **201**, and Second Core Network data source **102***b* with Network processors **201**. The Network processors **201** are also communicatively connected with Baseband processor/s **202**, which generate using one or more radio chains, and one or more radio antennas, the RANs, here First RAN **109***a* and Second RAN **109***b*. In the initial setup of the embodiment illustrated in FIG. **1**B, a First amount of wireless Access Spectrum **211***a* has been allocated to First RAN **109***a*, and a Second amount of wireless Access Spectrum has been allocated to Second RAN **109***b*.

FIG. **1**C illustrates one embodiment a possible allocation of wireless Access Spectrum to two Radio Access Networks (RANs). A certain amount of wireless Access Spectrum has been pre-allocated **211** to a wireless BS and to an associated plurality of two or more RANs. Further, all or part of the pre-allocated wireless Access Spectrum **211** may be dynamically allocated as a First amount of wireless Access Spectrum **211***a* to a First RAN **109***a* or as a Second amount of wireless Access Spectrum **211***b* to a Second RAN **109***b*. In FIG. **1**C, not all of **211** has been allocated to **211***a* or **211***b*. Rather, there is a small amount of frequency between **211***a* and **211***b* that has not been allocated, possibly as a guard frequency against inter-Operator interference. Similarly, there is a small amount of frequency on the left of **211***a*, in a frequency lower than the lowest boundary of the **211***a* range, that has not been allocated, and this, too, might be a guard frequency. In addition, there is a greater amount of frequency at a higher range than **211***b*, still within **211** but to the right of **211***b*, that has not been allocated, and this may be partially a guard frequency, possibly a reserve, possibly allocated to a different Operator or a different purpose. The main point is that the total frequency in **211***a* and **211***b* combined may equal, or maybe less than, but may not exceed, the pre-allocated wireless Access Spectrum **211**. Further, the allocation of **211** between **211***a* and **211***b* may be done at the same time as the allocation of **211**, or may be done after the allocation of **211**, but in all cases, no frequency is allocated among Operators until there has been or is simultaneously a pool of pre-allocated wireless Access Spectrum **211**.

FIG. **2** illustrates one embodiment of components comprising a system of a wireless Base Station (BS) **100** generating multiple Radio Access Networks (RANs) **109***a* & **109***b*, in which the two RANs **109***a* & **109***b* are sharing one radio transceiver chain **232**. In FIG. **2**, there is a single radio transceiver chain **232** utilized by the Baseband processors **202** to generate the RANs **109***a* and **109***b*. As described previously, a First amount of wireless Access Spectrum **211***a* has been allocated to First RAN **109***a*, and a Second amount of wireless Access Spectrum **211***b* has been allocated to Second RAN **109***b*. Since both **109***a* and **109***b* communicate with wireless BS **100** through the same radio transceiver chain **232**, the coverage areas of **109***a* and **109***b* will be either the same or very similar.

FIG. **3** illustrates one embodiment of components comprising a system of a wireless Base Station (BS) **100** communicating with multiple Radio Access Networks (RANs) **109***a* & **109***b*, in which each of two RANs **109***a* & **109***b* has its own radio transceiver chain **233***a* & **233***b*, and the RANs **109***a* & **109***b* share other resources within the wireless BS **100**. FIG. **3** has the same components has does FIG. **2**, except FIG. **3** does not have a single radio transceiver chain **232**. Rather, FIG. **3** has two transceiver chains, which are First radio transceiver chain **233***a* that is utilized by Baseband processor/s **202** to generate First RAN **109***a* using the First amount of wireless Access Spectrum **211***a*, and Second radio transceiver chain **233***b* that is utilized by Base Band processor/s **202** to generate Second RAN **109***b* using the Second amount of wireless Access Spectrum **211***b*. As shown in FIG. **3**, since each RAN has its own radio transceiver chains, the RAN coverage areas are essentially independent. The coverage areas might not overlap at all, might overlap slightly as is shown in FIG. **3**, or might overlap substantially as is shown in FIG. **2**.

In one embodiment, there is a wireless Base Station (BS) **100** system to directly communicate with Core Network data sources **102***a* & **102***b*, on one side, and to directly provide multiple corresponding Radio Access Networks (RANs) **109***a* & **109***b* on the other side. This system may include a network processor **201** operative to maintain at least two network Tunnels **105***a* & **105***b* extending directly to at least two corresponding Core Network data sources **102***a* & **102***b*, one or more Baseband processors **202** operative to create at least two RANs **109***a* & **109***b* substantially simultaneously, and one or more radio transceiver chains **232**, **233***a* and **233***b*, operative to accommodate the one or more Baseband processors **202** in creating the at least two RANs **109***a* & **109***b* substantially simultaneously. In one configuration of the embodiment, the system may be configured to split dynamically a pool of pre-allocated wireless Access Spectrum **211** between the at least two RANs **109***a* & **109***b* according to one or more criteria, reconfigure the at least one Baseband Processor **202** to maintain the at least two RANs **109***a* & **109***b* according to the split of spectrum between the two RANs **109***a* & **109***b*, and operate the at least two RANs **109***a* & **109***b* using data communicated with the corresponding at least two Core Network data sources **102***a* & **102***b* via the corresponding at least two network Tunnels **105***a* & **105***b*.

In an alternative embodiment of the embodiment just described, at least one of the criteria used to split dynamically a pool of pre-allocated wireless Access Spectrum **211** between at least two RANs **109***a* & **109***b*, is based on dynamic data rate requirements of at least one of the Core Network data sources **102***a* & **102***b*.

In another alternative embodiment of the embodiment described above, at least one of the criteria used to split dynamically a pool of pre-allocated wireless Access Spectrum **211** between at least two RANs **109***a* & **109***b*, is based on measuring data rates over at least one of the RANs **109***a* & **109***b*.

In another alternative embodiment of the embodiment just described, at least one of the criteria used to split dynamically a pool of pre-allocated wireless Access Spectrum **211** between at least two RANs **109***a* & **109***b*, is based on measuring data rates over at least one of the network Tunnels **105***a* & **105***b*.

In another alternative embodiment of the embodiment just described, the dynamic split of pre-allocated wireless Access Spectrum creates at least two amounts of wireless Access Spectrum, and each amount of wireless Access Spectrum after the split is allocated to one of the at least two RANs.

In one possible configuration of the alternative embodiment in which each amount of wireless Access Spectrum after the split is allocated to one of the at least two RANs, at least one of the amounts of wireless Access Spectrum **211***a* & **211***b* allocated to the RANs **109***a* & **109***b*, is smaller than the other amount of allocated wireless Access Spectrum **211***a* & **211***b*. In other words, either **211***a* is greater than **211***b*, or **211***b* is greater than **211***a*, but in this embodiment **211***a* is not equal to **211***b*.

FIG. **4** illustrates one embodiment of a Baseband processor **202** in a system of a wireless Base Station (BS) **100** generating multiple Radio Access Networks (RANs) **109***a* & **109***b*, in which two RANs **109***a* & **109***b* are sharing one radio transceiver chain **232**. In this embodiment, the Baseband processor **202** may be reconfigured by programming. In one possible embodiment, reconfiguration by programming is implemented by two software changes, termed in FIG. **4**, "First software instance **401***a*" and "Second software instance **401***b*". In **401***a*, the software instance is associated with First RAN **109***a*, and **401***a* creates Baseband signal **440***a*, having a bandwidth that is dynamically related to the amount of wireless Access Spectrum **211***a* allocated to First RAN **109***a*. Correspondingly, in **401***b* the software instance is associated with Second RAN **109***b*, and **401***b* creates Baseband signal **440***b*, having a bandwidth that is dynamically related to the amount of wireless Access Spectrum **211***b* allocated to First RAN **109***b*. In FIG. **4**, the relative bandwidth between **109***a* and **109***b* are intimately related, since the total amount of bandwidth allocated to two RANs **109***a* & **109***b* cannot exceed the initial allocation **211**. Similarly, the relative bandwidths of the Baseband signals **440***a* & **440***b* are intimately related, since the two bandwidths together cannot exceed the allocation **211**.

FIG. **5** illustrates one embodiment of a Baseband processor **202** in a system of a wireless Base Station (BS) **100** generating multiple Radio Access Networks (RANs) **109***a* & **109***b*, in which each of two RANs **109***a* & **109***b* has its own radio transceiver chain, **233***a* for First RAN **109***a* and **233***b* for Second RAN **109***b*. In this embodiment, First software instance **401***a* creates Baseband signal **440***a*, which the Baseband processor **202** communicates to the First radio transceiver chain **233***a*, which communicates Baseband signal **440***a* over allocated frequency **211***a* to First RAN **109***a*. Also in this embodiment, Second software instance **401***b* creates Baseband signal **440***b*, which the Baseband processor **202** communicates to the Second radio transceiver chain **233***b*, which communicates Baseband signal **440***b* over allocated frequency **211***b* to Second RAN **109***b*.

FIG. **6**A and FIG. **6**B illustrate one embodiment of a Baseband processor **202** in a system of a wireless Base Station (BS) **100** generating multiple Radio Access Networks (RANs) **109***a* & **109***b*, in which two RANs **109***a* & **109***b* are sharing one radio transceiver chain **232**. In this embodiment, the Baseband processor **202** may be reconfigured by programming. In one possible embodiment, reconfiguration by programming is implemented by a Dynamic signal synthesizer **501** dynamically synthesizing a single compound signal **550** on Baseband processor **202**. The single compound signal **550** has at least two frequency portions **550***a* & **550***b*, in which each frequency portion is associated with one of the RANs **109***a* & **109***b*, and each of the frequency portions **550***a* & **550***b* is dynamically related to the amount of wireless Access Spectrum allocated **211***a* & **211***b* to the RANs **109***a* & **109***b*. As an example, **501** creates compound signal **550** which includes a frequency portion **550***a* associated with First RAN **109***a* and dynamically related to First amount of wireless Access Spectrum **211***a*, and which also includes frequency portion **550***b* associated with Second RAN **109***b* and dynamically related to Second amount of wireless Access Spectrum **211***b*. In this sample embodiment, the dynamic signal synthesizer **501** fills the role formerly filled by First software instance **401***a* and Second software instance **401***b* in FIG. **4**. Since FIG. **6**A, like FIG. **4**, has only one radio transceiver chain **232**, the coverage areas of **109***a* and **109***b* overlap substantially.

In one embodiment, a wireless Base Station (BS) **100** system directly communicates with Core Network data sources **102***a* & **102***b*, on one side, and directly provides multiple corresponding Radio Access Networks (RANs) **109***a* & **109***b* on the other side, in which different amounts of wireless Access Spectrum have been allocated to RANs **109***a* & **109***b*, the following additional elements may appear. (1) The at least one Baseband processor **202** is programmable to an alternative configuration. (2) The Baseband processor **202** is reconfigured by at least two software instances **401***a* & **401***b* on Baseband processor **202**, each software instance associated with at least one of the RANs **109***a* & **109***b*, and each software instance **401***a* & **401***b* creates a Baseband signal **440***a* & **440***b* that has a bandwidth dynamically related to the amount of wireless Access Spectrum allocated to the RAN by the dynamic split of wireless Access Spectrum. For example, **401***a* creates **440***a* that is dynamically related to **211***a*, and **401***b* creates **440***b* that is dynamically related to **211***b*. In one alternative embodiment of this embodiment, there is only one radio transceiver chain **232**, and the Baseband signals **440***a* & **440***b* of the least two software instances **401***a* & **401***b* are fed to this one chain **232**, thereby generating the at least two RANs **109***a* & **109***b*, each RAN driven by one of the corresponding Baseband signals **109***a* by **401***a* and **109***b* by **401***b*. In a different alternative embodiment of the embodiment described above, there are two radio transceiver chains **233***a* & **233***b* rather than the one chain **232**, so **401***a* creates **440***a* that is fed to transceiver chain **233***a* which then generates First RAN **109***a*, and **401***b* creates **440***b* that is fed to transceiver chain **233***b* which then generates Second RAN **109***b*.

In one embodiment a wireless Base Station (BS) **100** system directly communicates with Core Network data sources **102***a* & **102***b*, on one side, and directly provides multiple corresponding Radio Access Networks (RANs) **109***a* & **109***b* on the other side, in which different amounts of wireless Access Spectrum have been allocated to RANs **109***a* & **109***b*, the following additional elements may appear. (1) The at least one Baseband processor **202** is programmable to an alternative configuration. (2) The Baseband processor **202** is reconfigured by a dynamic signal synthesizer **501** dynamically synthesizing a single compound signal **550** on the at least one Baseband processor **202**, the compound signal **550** having at least two frequency portions **550***a* & **550***b*, each of the two frequency portions **550***a* & **550***b* associated with one of the at least two RANs **109***a* & **109**B, and each of the frequency portions **550***a* & **550***b* is dynamically related to the amount of wireless Access Spectrum **550***a* & **550***b* allocated for each of the RANs **109***a* & **109***b* by the frequency split.

In an alternative embodiment of the embodiment described immediately above, there is a single radio transceiver chain **232**, and the single compound signal **550** is fed to the single radio transceiver chain **232**, thereby generating the at least two RANs **109***a* & **109***b*, in which each is driven by one of the

two frequency portions **550***a* & **550***b*. In one possible configuration of this alternative embodiment of the embodiment described immediately above, each of the two RANs is either WiMAX or LTE, the single compound signal **550** is an Orthogonal Frequency Division Multiple Access (OFDMA) signal, and the two frequency portions **550***a* & **550***b* comprises at least one unique sub-channel of the OFDMA signal.

FIG. **7** illustrates one embodiment of components comprising a system communicating between Core Network data sources **102***a* & **102***b* and wireless Subscriber Stations **108***a* & **108***b*, in which a first data set is communicated **300***a* from First Core Network data source **102***a* via the logical link network Tunnel **105***a* to wireless Base Station **100**, then to Network processor **201**, Baseband processor **202**, and First radio transceiver chain **233***a*, after which the first data set is conveyed **301***a* by the wireless BS **10** to the First RAN **109***a*, and finally to a first set of wireless Subscriber Stations **108***a*. Also in this embodiment, a second data set is communicated **300***b* from Second Core Network data source **102***b* via the logical link network Tunnel **105***b* to wireless Base Station **100**, then to Network processor **201**, Baseband processor **202**, and Second radio transceiver chain **233***b*, after which the second data set is conveyed **301***b* by the wireless BS **10** to the Second RAN **109***a*, and finally to a second set of wireless Subscriber Stations **108***b*. FIG. **7** illustrates the communication path for both data sets between each Core Network and its corresponding set of wireless Subscriber Stations. Of course, data traffic travels in both direction, from Core Networks through various stages to wireless Subscriber Stations, and from wireless Subscriber Stations through various stages to Core Networks.

FIG. **8** is a flow diagram illustrating one method for dynamically generating a plurality of Radio Access Networks (RAN) **109***a* & **109***b* by a single wireless Base Station (BS) **100**. In step **1021**, determining dynamically first and second amounts of wireless Access Spectrum **211***a* & **211***b* needed by a wireless BS **100** to wirelessly convey data from a first and a second corresponding Core Network data sources **102***a* & **102***b*. In step **1022**, allocating the first and the second amounts of wireless Access Spectrum **211***a* & **211***b*, out of a pool of pre-allocated wireless Access Spectrum **211** belonging to the wireless BS **100**, to a first RAN **109***a* and a second RAN **109***b*, respectively, of the wireless BS respectively. In step **1023**, the wireless BS **100** communicating first and second data sets **300***a* & **300***b*, with the first and the second Core Network data sources **102**A & **102***b*, respectively. In step **1024**, the wireless BS **100** conveying the first and second data sets **301***a* & **301***b*, over the first and second RANs **109***a* & **109***b*, respectively, to first and second sets of wireless Subscriber Stations (SS) **108***a* & **108***b*, respectively.

In a first possible implementation of the method just described, further determining from time to time the first and the second amounts of wireless Access Spectrum **211***a* & **211***b* needed by the wireless BS **100** to wirelessly convey **301***a* & **301***b* the first and second data sets, and allocating from time to time the first and the second amounts of wireless Access Spectrum **211***a* & **211***b*.

In this first possible implementation of the method just described, one further possible implementation is that the first and second amounts of wireless Access Spectrum **211***a* & **211***b* are determined, at least in part, from first and second data rates associated with communicating the data sets **300***a* & **300***b*. In this further possible implementation of the possible implementation of the method just described, the first and second data rates associated with communicating the data sets **300***a* & **300***b* may be measured, or such data rates may be determined by querying the first and second Core Network data sources **102***a* & **102***b*, or it is possible to both measure the data rates and also query the Core Network data sources **102***a* & **102***b*.

In this first possible implementation of the method described above for dynamically generating a plurality of RANs **109***a* & **109***b* by a single wireless BS **100**, a second further possible implementation is that at some point in time most of the pool of pre-allocated wireless Access Spectrum **211** is allocated as the first amount of wireless Access Spectrum **211***a* to the First RAN **109***a*. In this same second further possible implementation, in an additional embodiment, at some point in time most of the pool of pre-allocated wireless Access Spectrum **211** is allocated as the second amount of wireless Access Spectrum **211***b* to the Second RAN **109***b*.

In a second possible implementation of the method described above, further communicating the first and second data sets **300***a* & **300***b* with the first and second Core Network data sources **102***a* & **102***b*, using at least one Backhaul link **105**.

In this second possible implementation of the method described above, one further possible implementation is that at least one Backhaul link **105** comprises a first network Tunnel **105***a*, connecting the first Core Network data source **102***a* with the wireless BS **100**, and connecting the second Core Network data source **102***b* with the wireless BS **100**.

In this same further possible implementation to the second possible implementation of the method described above, an additional embodiment would include the following additional elements. (1) The wireless BS **100** is an integrated Pico-Base Station. (2) The network Tunnels **105***a* & **105***b* are directly connected to the first and second Core Network data sources **102***a* & **102***b*, respectively. (3) The Pico-Base Station substantially does not require a dedicated infrastructure to facilitate connectivity with the Core Network data sources **102***a* & **102***b* other than the at least one Backhaul link **105** and an IP Network **101** comprising the Core Network data sources **102***a* & **102***b*.

In this second possible implementation of the method described above, a second further possible implementation is that the first data set is communicated **300***a* over a first Backhaul link, and a second data set is communicated over a second Backhaul link. Element **105** shows a single Backhaul link, but in this further possible implementation, there are two Backhaul links, although that is not illustrated in the Figures.

In a third possible implementation of the method described above, the First Core Network data source **102***a* belongs to a first Operator, the Second Core Network data source **102***b* belongs to a second Operator, the First RAN **109***a* is associated with an identity of the first Operator, and the Second RAN **109***b* is associated with an identity of the second Operator. The phrase "associated with" in this sense means that the name of the network is broadcast within the RAN transmissions. Hence, a First RAN **109***a* associated with the identity of the first Operator will broadcast, together with the RAN **109***a* transmissions, the name of the first network or the other identity of the first network chosen by the first Operator. Similarly, a Second RAN **109***b* associated with the identity of the second Operator will broadcast, together with the RAN **109***b* transmissions, the name of the second network or the other identity of the second network chosen by the second Operator.

FIG. **9** is a flow diagram illustrating one method for servicing multiple cellular Operators via a single wireless Base Station (BS) **100**, utilizing dynamic allocation of spectrum. In step **1031**, a wireless BS **100** communicating first **300***a* and a second **300***b* data sets with a First Core Network data source **102***a* belonging to a first cellular Operator and with a Second

Core Network data source **102***b* belonging to a second cellular Operator respectively, over first and second network Tunnels **105***a* & **105***b*, respectively. In step **1032**, the wireless BS **100** utilizing first and second amounts of wireless Access spectrum **211***a* & **211***b*, respectively, to convey the first **301***a* and second **301***b* data sets over first **109***a* and second **109***b* RANs, respectively, to first and second sets of wireless Subscriber Stations (SS) **108***a* & **108***b*, respectively. In step **1033**, determining that the first amount of wireless Access Spectrum **211***a* is not sufficient to convey **300***a* the first data set. In step **1034**, increasing the first amount of wireless Access Spectrum **211***a* at the expense of the second amount of wireless Access Spectrum **211***b*, thereby making the first amount of wireless Access Spectrum **211***a* better suited to convey **301***a* the first data set.

In a first possible implementation of the method just described, increasing the first amount of wireless Access Spectrum **211***a* at the expense of the second amount of wireless Access Spectrum **211***b* further comprises determining a third amount of wireless Access Spectrum that can be reduced from the second amount of wireless Access Spectrum **211***b* without substantially impairing the ability of the second amount of wireless Access Spectrum **211***b* to convey **301***b* the second data set, reducing the third amount of Wireless Access Spectrum from the second amount of wireless Access Spectrum **211***b*, and adding the third amount of wireless Access Spectrum to the first amount of wireless Access Spectrum **211***a*.

In a second possible implementation of the method described above, increasing the first amount of wireless Access Spectrum **211***a* at the expense of the second amount of wireless Access Spectrum **211***b* further comprises determining a third amount of wireless Access Spectrum to be reduced from the second amount of wireless Access Spectrum **211***b* and to be added to the first amount of wireless Access Spectrum **211***a*, such that the third amount of wireless Access Spectrum is operative to substantially equate the ability of the first amount of wireless Access Spectrum **211***a* to convey **301***a* the first data set with the ability of the second amount of wireless Access Spectrum **211***b* to convey **301***b* the second data set, reducing the third amount of Wireless Access spectrum from the second amount of wireless Access Spectrum **211***b*, and adding the third amount of wireless Access Spectrum to the first amount of wireless Access Spectrum **211***a*.

It is noted that: (1) In some embodiments, there is a fully-integrated Base Station with an ability to handle multiple bands. (2) In some embodiments, there is an array of assignable Core Network interfaces which allow multiple Operators to share the same Base Station equipment and the same physical backhaul interface. (3) In some embodiments, there is load balancing between Operators to share one or more of wireless Access Spectrum, radio antennas, available radio transmit power, backhaul, and Baseband processing power. (4) In some embodiments, both licensed and unlicensed frequencies are supported in a fully-integrated Base Stations. (5) In some embodiments, there is dynamic reallocation of wireless Access Spectrum from a relatively lightly loaded Operator to a relatively heavily loaded Operator. (6) In some embodiments, a dedicated Gateway separates traffic between the Core Networks and the Base Station. (7) In some embodiments, a fully integrated multi-Operator Base Station allows multiple Operators to share many different kinds of resources, such as, but not by limitation, wireless Access Spectrum, antenna, radio chain, transmit power, processing, backhaul to a centralized processing unit, and others. (8) Various of embodiments described herein offer the flexibility of a compact and fully integrated Base Station that permit balancing in the employment of many different kinds of resources, including, by example and not by limitation, wireless Access Spectrum, antenna, radio chain, transmit power, processing, and backhaul to a centralized processing unit that is itself part of that Base Station. (9) A multi-Operator Base Station would be ideal for wholesalers who build networks to be leased out to Operators. In other words, the availability of a multi-Operator Base Station allows new designs for networks intended specifically to allow the sharing of resources.

FIG. **10**A illustrates one embodiment of components in a system. In FIG. **10**A, there is a wireless Base Station (BS) **100***b*, which includes a Baseband subsystem **502** communicatively connected to multiple radio transceiver chains **533***a*, **553***b*, **553***c*, and **533**N. Each radio chain is communicatively connected to an antenna. In FIG. **10**A, radio transceiver chain **533***a* is communicatively connected to antenna **577***a*, **553***b* to **577***b*, **533***c* to **577***c*, and **533**N to **577**N. Each antenna communicates over a wireless channel with a group of Subscriber Stations. In FIG. **10**A, there are two wireless channels, which are illustrated as **555***a* and **555**K. **555***a* is the radio channel that is used by the two antennas **577***a* and **577***b*. **555**K is the wireless channel that is used by antenna **577***c* and **577**N.

FIG. **10**B illustrates one embodiment of components in a system. In Baseband subsystem **502**, there are N digital ports, illustrated by **538***a*, **538***b*, **538***c*, and **538**N. Each digital port is connected to an Analog-Digital interface located in a radio transceiver chain. Thus, digital port **538***a* is connected to Analog-Digital interface **539***a* located within radio transceiver chain **533***a*. Similarly, **538***b* is connected to **539***b* within **533***b*, **538***c* is connected to **539***c* within **533***c*, and **538**N is connected to **539**N within **533**N. One possible conversion, but not the only possibility, is a digital communication from the Baseband subsystem **502** to any one of the digital ports, then converted by the Analog-Digital interface connected to that digital port, and then communicated via the corresponding radio transceiver chain to a one or more Subscriber Stations. For example, a digital signal from **502** to **538***a*, converted to analog by **539***a*, and then transmitted by **533***a* to a group of Subscriber Stations. Another possible conversion, but not the only possibility, is an analog communication from a Subscriber Station, to a radio transceiver chain, converted from analog to digital by the Analog-Digital interface within the radio transceiver chain, then communicated to the corresponding digital port, and finally communicated to the Baseband subsystem. For example, an analog signal from a Subscriber Station to radio transceiver chain **533***b*, converted to digital by Analog-Digital interface **539***b*, communicated to Digital port **538***b*, and then communicated to Baseband subsystem **502**.

In FIG. **10**B, separate paths are not shown within the Baseband subsystem **502** to the Subscriber Stations. The intent is that the Baseband subsystem **502** is sufficiently strong that it communicates directly with each of the subsystems, including subsystem **538***a*-**539***a*-**533***a*, subsystem **538***b*-**539***b*-**533***b*, subsystem **538***c*-**539***c*-**533***c*, and subsystem **538**N-**539**N-**533**N.

FIG. **10**C illustrates one embodiment of multiple signals within a Baseband system **502**. In FIG. **10**C, Synthesis of digital Baseband signals **55***a* creates two signals, each of which ultimately communicates with Subscriber Stations over wireless channel **555***a*. One such signal is **55***a***1** created by **55***a* and conveyed to **538***a*, then to **539***a* and to **533***a*, then over wireless channel **555***a* to Subscriber Stations. Similarly, a signal **55***a***2** synthesized from **55***a* is conveyed from **55***a* to **538***b* to **539***b* to **533***b*, then over the same wireless channel **555***a* to Subscriber Stations. The use of the same wireless channel **555***a* for both signals, indicates that the same com-

munication is being sent by multiple signals, at substantially the same time, from the Baseband system **502** to the Subscriber Stations, or conversely that a communication from one Subscriber Station will be received on wireless channel **555** and will travel via both **533***a* to **502** and **533***b* to **502**. A similar process occurs between Synthesis of digital Baseband signal **55**N and Subscriber Stations via wireless channel **555**K, in which one signal **55N1** is conveyed from **502** to **538***c* to **539***c* to **533***c* to **555**K to the Subscriber Stations, or vice versa from one Subscriber Station to **555***k*, to **533***c*, to **539***c*, to **538***c* to **55**N within Baseband subsystem **502**. A second signal **55N2** is conveyed from **502** to **538**N to **539**N to **533**N to **555**K to the Subscriber Stations, or conversely from a Subscriber Station to **555**K to **533**N to **539**N to 0 **538**N and to **55**N within Baseband subsystem **502**.

Letter K representing the number of wireless channels **555***a*-**555**K in use at any particular time, is by intent not the same as letter N representing the number of radio transceiver chains **553***a*-**553** N. K may be equal N, indicating a one-to-one match between number of wireless channels **555***a*-**555**K in operation and number of signals **55***a***1** & **55***a***2** and **55N1** & **55N2** from **502** through syntheses of digital signals **55***a* & **55**N to radio transceiver chains **533***a*-**533**N, hence to antennas **577***a*-**577**N and Subscriber Stations. K may be less than N, indicating there are fewer wireless channels **555***a*-**555**K than signals **55***a***1** & **55***a***2** and **55N1** & **55N2**, and this may occur when a transmission is to be repeated in two more simultaneously conveyed signals. When a transmission is made on two or more signals as opposed to only one signal, even when all the signals are propagated on the same radio frequency, that transmission will typically have a higher radio system gain than a transmission on only one signal, which means generally that a transmission with multiple signals can have, in comparison to a transmission with one signal, any of a higher quality link (typically measured by S/N ratio), a greater distance propagation, a greater penetration power, higher data rate, or a combination of any of the foregoing.

In some embodiments, the number of Syntheses of digital Baseband signals **55***a* & **55**N may be dynamically altered to meet temporal system demands. In some embodiments, the number of wireless channels **555***a*-**555**K may be dynamically altered to meet temporal system demands. The number of each of these elements, the Syntheses and the wireless channels, is independent from the numbers of the other elements, except that K channels may not exceed N communication paths, and the number of syntheses may not exceed N digital Baseband signals.

There are many alternative embodiments in the generation of signals to and from antennas the Subscriber Stations. For example, antennas may be a single antenna connected to a radio transceiver chain, or there may be phased array signals in use, or MIMO signal in use, or any other communication configuration. For example, there may be phased-array coherent reception, Maximal Ratio Combining (MRC), Minimum Mean Square Error (MMSE), Maximum Likelihood (ML), or any other number of algorithms in the transmission or reception of a wireless signal.

In one embodiment, there is a wireless Base Station (BS) system **100***b*, operative to assign dynamically a plurality of radio transceiver chains **533***a*-**533**N among a varying number of wireless channels **555***a*-**555**N. This wireless BS system **100***b* may include a Baseband (BB) subsystem **502**, which itself may include N digital ports **538***a*-**538**N, operative to synthesize **55***a* & **55**N N digital Baseband (BB) signals **55***a***1** & **555***a***2** and **55***n***1** & **55***n***2** associated with K wireless channels **555***a* & **555**K, wherein (1) N is equal to at least 2, (2) K is equal to at most N, and (3) K is equal to at least 1. The wireless BS system **100***b* may also include N radio transceiver chains **533***a*-**533**N, each of which may be connected to one of the N digital ports **538***a*-**538**N of the BB subsystem **502** via an Analog-Digital interface **539***a*-**539**N. The wireless BS system **100***b* may be configured to (A) set dynamically K according to a first criterion, wherein K is a number between 1 and N, (B) assign dynamically the N radio transceiver chains **533***as*-**533**N among the K wireless channels **555***a*-**555**K according to a second criterion such that each radio transceiver chain **533***a*-**533**N is assigned to only one of the wireless channels **555***a*-**555**K, (C) synthesize **55***a*-**55**N, by the BB subsystem **502**, the N digital BB signals **55***a***1** & **55***a***2** and **55N1** & **55N2** associated with the K wireless channels **555***a*-**555**K, and (D) input the N digital BB signals to the N radio transceiver chains **553***a*-**533**N via the corresponding N digital ports **538***a*-**538**N and the corresponding Analog-Digital interfaces **539***a*-**539**N, thereby transmitting the K wireless channels **555***a*-**555**K via the N radio transceiver chains **533***a*-**533**N. This embodiment will be called "the Dynamic Assignment embodiment", and seven alternatives to this embodiment are described below.

In a first alternative embodiment of the Dynamic Assignment embodiment, the number of wireless channels K **555***a*-**555**K is smaller than the number of radio transceiver chains N **533***a*-**533**N, which may mean that at least one of the wireless channels **555***a*-**555**K is transmitted via at least two of the radio transceiver chains **533***a*-**533**N. In one configuration of this alternative embodiment, at least two of the N digital Baseband signals **55***a***1** & **55***a***2** and **55N1** & **55N2** driving the at least two of the radio transceiver chains **533***a*-**533**N comprise at least two Multiple Input Multiple Output (MIMO) signals, thereby transmitting the at least one of the wireless channels using a MIMO scheme. In a second configuration of this alternative embodiment, at least two of the N digital Baseband signals **55***a***1** & **55***a***2** and **55N1** & **55N2** driving the at least two of the radio Transceiver chains **533***a*-**533**N comprise at least two phased-array signals, thereby transmitting the at least one of the wireless channels **555***a*-**555**K using a phased-array scheme comprising the at least two of the radio transceiver chains **533***a*-**533**N.

FIG. **11** illustrates one embodiment of multiple signals within a Baseband system **502**. FIG. **11** is different in two respects from FIG. **10**C. First, there is only one Synthesis of digital Baseband signals **56***a* in FIG. **11**, as opposed to two in FIG. **10**C. The meaning is that all of the N digital Baseband signals in FIG. **11** **56***a***1**, **56***a***2**, **56***a***3**, and **56***a*N, are generated by a signal Synthesis **56***a* within the Baseband subsystem **502**. Second, in FIG. **11** there is only one wireless channel **556***a*, driven by the same four radio transceiver chains **533***a*-**533**N, whereas in FIG. **10**C there were two wireless channels from the same four radio transceiver chains **533***a*-**533**N. Where there are more chains driving one wireless channel, as there are here in FIG. **11**, (1) the system gain for this wireless channel will be higher, in both directions, that is, from the radio transceiver chains to the Subscriber Stations, and from the Subscriber Stations to the radio transceiver chains, or (2) the data capacity of this wireless channel will increase.

FIG. **12** illustrates one embodiment of a Baseband subsystem **502** in a wireless BS system **100***b*, operative to assign dynamically a plurality of radio transceiver chains **533***a*-**533**N among a varying number of wireless channels **555***a*-**555**N. The Baseband system **502** includes a single Baseband processor **601**, which is operative to generate substantially simultaneously the K wireless channels **555***a*-**555**K and the corresponding N Baseband digital signals **55***a***1** & **55***a***2** and **55N1** & **55N2**, according to the setting of K.

FIG. **13** illustrates one embodiment of a Baseband subsystem **502** in a wireless BS system **100***b*, operative to assign dynamically a plurality of radio transceiver chains **533***a*-**533**N among a varying number of wireless channels **555***a*-**555**N. The Baseband system comprises two or more Baseband processors **601***a* & **601**K, which are operative to generate substantially simultaneously the K wireless channels **555***a*-**555**N and the corresponding N Baseband digital signals **55***a***1** & **55***a***2** and **55**N**1** & **55**N**2**, according to the setting of K.

FIG. **14** illustrates one embodiment of the subsystem described in FIG. **13**. In FIG. **14**, there is a Configurable digital interconnect subsystem **690**, which interconnects each of the Baseband processors **601***a*-**601**K with at least some of the N digital ports **538***a*-**538**N, according to the setting of K and according to the assignment of the N radio transceiver chains **533***a*-**533**N among the K wireless channels **555***a*-**555**K.

In a second alternative embodiment of the Dynamic Assignment Embodiment, there is a wireless Base Station (BS) system **100***b*, operative to assign dynamically a plurality of radio transceiver chains **533***a*-**533**N among a varying number of wireless channels **555***a*-**555**N. This wireless BS system **100***b* may include a Baseband (BB) subsystem **502**, which itself may include N digital ports **538***a*-**538**N, operative to synthesize **55***a* & **55**N N digital Baseband (BB) signals **55***a***1** & **555***a***2** and **55***n***1** & **55***n***2** associated with K wireless channels **555***a* & **555**K, wherein (1) N is equal to at least 2, (2) K is equal to at most N, and (3) K is equal to at least 1, wherein the wireless BS system **100***b* may be configured to set dynamically K according to the distance between a Subscriber Station and the wireless BS **100***b*, such that during the operation phase of the wireless BS **100***b* when the Subscriber Stations are relatively distant from the wireless BS **100***b*, K is set to 1, thereby creating a single wireless channel **556***a* transmitting via the N radio transceiver chains **533***a*-**533**N and increasing the range of the single wireless channel **556***a* to facilitate communication with the relatively distant Subscriber Station. This alternative embodiment will be called "embodiment where initial K=1", and several alternative embodiments to this embodiment will be described below.

In a first alternative embodiment of an embodiment in which initial K=1, N digital Baseband signals **56***a*-**56**N driving the N radio transceiver chains **533***a*-**533**N comprise N phased-array signals, thereby transmitting the single wireless channel **556***a* using a phased-array scheme comprising the N radio transceiver chains **533***a*-**533**N, wherein the Baseband subsystem **502** is reconfigured to generate the N phased-array signals accordingly.

In a second alternative embodiment of an embodiment in which initial K=1, during a later operation phase of the wireless BS **100***b* when the Subscriber Stations become closer to the wireless BS **100***b*, K is set to at least two, such that each of the wireless channels **555***a* & **555**K is transmitting via less than the N radio transceiver chains **533***a*-**533**N, thereby decreasing the range of the wireless channels **555***a* & **555**K, but increasing data throughput of the wireless BS **100***b*.

In such second alternative embodiment of an embodiment in which initial K=1, one alternative configuration occurs during or after a transition from a single wireless channel operation to at least two wireless channels operation. At or after this transition, the Baseband subsystem **502** is reconfigured to transition between a single wireless channel N-phased-array operation using wireless channel **556***a* to a multiple wireless channels MIMO operation using wireless channels **555***a*-**555**K.

In such second alternative embodiment of an embodiment in which initial K=1, one alternative configuration occurs during or after a transition from a single wireless channel operation to at least two wireless channels operation. At or after such transition, the Baseband subsystem **502** is reconfigured to transition between a transmission scheme including a single wireless channel N-level coherent phase transmission, to a transmission scheme comprising multiple wireless channels MIMO operation. In this alternative configuration, an additional possibility is that the Baseband subsystem **502** is reconfigured to transition between an N-level combining-algorithm reception mode to a multiple wireless channels MIMO reception mode, in which the N-level combining-algorithm reception mode may be any one of phased-array coherent reception, Maximal Ratio Combining (MRC), Minimum Mean Square Error (MMSE) and Maximum Likelihood (ML), or any combination of such alternative reception modes.

In such second alternative embodiment of an embodiment in which initial K=1, one alternative configuration occurs during or after a transition from a single wireless channel operation to at least two wireless channels operation. At or after such transition, the Baseband subsystem **502** is reconfigured to transition between a transmission scheme including Cyclic Delay Diversity (CDD), to a transmission scheme comprising multiple wireless channels MIMO operation. In this alternative configuration, an additional possibility is that the Baseband subsystem **502** is reconfigured to transition between an N-level combining-algorithm reception mode to a multiple wireless channels MIMO reception mode, in which the N-level combining-algorithm reception mode may be any one of Phased-array coherent reception, Maximal Ratio Combining (MRC), Minimum Mean Square Error (MMSE) and Maximum Likelihood (ML), or any combination of such alternative reception modes.

In such second alternative embodiment of an embodiment in which initial K=1, one alternative configuration occurs during the initial operation phrase of the wireless BS **100***b*, when all the aggregated transmission power of the N radio transceiver chains **533***a*-**533**N is used for the transmission of a single wireless channel **556***a*, thereby maximizing the range of the single wireless channel **556***a*. In this alternative configuration, a further configuration occurs in a later operation phase of the wireless BS **100***b*, when each of the wireless channels **555***a*-**555**K is transmitting with less than the N radio transceiver chains **533***a*-**533**N, and therefore with less power than the aggregated transmission power of the N radio transceiver chains **533***a*-**533**N, thereby decreasing the range of each of the wireless channels **555***a*-**555**N and decreasing inter-cell interferences with close-by wireless Base Stations.

In a third alternative embodiment of the Dynamic Assignment embodiment, there is a wireless Base Station (BS) system **100***b*, operative to assign dynamically a plurality of radio transceiver chains **533***a*-**533**N among a varying number of wireless channels **555***a*-**555**N. Such system includes a Baseband subsystem **502** comprising N digital ports **538***a*-**538**N, operative to synthesize **55***a*-**55**N N digital Baseband signals **55***a***1** & **55***a***2** and **55**N**1** & **55**N**2** associated with K wireless channels **555***a*-**555**K, wherein N is equal to at least 2, K is equal to at most N, and K is equal to at least 1. The Baseband processor **502** includes a single Baseband processor **601** operative to generate substantially simultaneously the K wireless channels **555***a*-**555**N and the corresponding N digital Baseband signals **55***a***1** & **55***a***2** and **55**N**1** & **55**N**2**, according to the setting of K. In this embodiment, one configuration is where the Baseband processor **601** comprises an ASIC. In this embodiment, an alternative configuration is that the

Baseband processor **601** comprises an FPGA. In this embodiment, an alternative configuration is that the Baseband processor **602** comprises a Digital Signal Processor (DSP). In the alternative configuration in which the Baseband processor **602** comprises a DSP, the simultaneous generation of K wireless channels **555***a*-**555**N and the corresponding N digital Baseband signals **55***a***1** & **55***a***2** and **55**N**1** & **55**N**2**, is done at least in part in software running on the DSP.

In a fourth alternative embodiment of the Dynamic Assignment embodiment, there is a wireless Base Station (BS) system **100***b*, operative to assign dynamically a plurality of radio transceiver chains **533***a*-**533**N among a varying number of wireless channels **555***a*-**555**N. The system includes a Baseband subsystem **502**, which comprises at least two Baseband processors **601***a* & **601**K operative to generate substantially simultaneously K wireless channels **555***a*-**555**N and the corresponding N digital Baseband signals **55***a***1** & **55***a***2** and **55**N**1** & **55**N**2**, according to the setting of K. In one configuration of this fourth alternative embodiment, each of the Baseband processors **601***a* & **601**K is operative to generate one of the K wireless channels **555***a*-**555**N and the corresponding N digital Baseband signals **55***a***1** & **55***a***2** and **55**N**1** & **55**N**2**.

In a fifth alternative embodiment of the Dynamic Assignment embodiment, there is a wireless Base Station (BS) system **100***b*, operative to assign dynamically a plurality of radio transceiver chains **533***a*-**533**N among a varying number of wireless channels **555***a*-**555**N. In this system, the second criterion is based on assigning more radio transceiver chains to wireless channels requiring longer range.

In one configuration of this fifth alternative embodiment, in order to achieve long range, radio transceiver chains **533***a*-**533**N convey N-level coherent phase transmissions, and receives combinable signals enabling utilization of reception algorithms such as (1) Phased-array coherent reception, (2) Maximal Ratio Combining (MRC), (3) Minimum Mean Square Error (MMSE) and (4) Maximum Likelihood (ML). In a further possible alternative embodiment of this configuration, the Baseband subsystem **502** is reconfigured to use the combinable signals as at least some of the N digital Baseband signals **55***a***1** & **55***a***2** and **55**N**1** & **55**N**2**, upon exercising the assignment based on the second criterion.

In one configuration of this fifth alternative embodiment, in order to achieve long rang, radio transceiver chains **533***a*-**533**N convey Cyclic Delay Diversity (CDD) signals, and/or receive combinable signals enabling utilization of reception algorithms such as (1) Phased-array coherent reception, (2) Maximal Ratio Combining (MRC), (3) Minimum Mean Square Error (MMSE) and (4) Maximum Likelihood (ML). In a further possible alternative embodiment of this configuration, the Baseband subsystem **502** is reconfigured to use the combinable signals as at least some of the N digital Baseband signals **55***a***1** & **55***a***2** and **55**N**1** & **55**N**2**, upon exercising the assignment based on the second criterion.

In a sixth alternative embodiment of the Dynamic Assignment embodiment, there is a wireless Base Station (BS) system **100***b*, operative to assign dynamically a plurality of radio transceiver chains **533***a*-**533**N among a varying number of wireless channels **555***a*-**555**N. In this system, the second criterion is based on assigning more radio transceiver chains **533***a*-**533**N to wireless channels requiring relatively high data throughput rates, and the radio transceiver chains **533***a*-**533**N convey MIMO signals the help obtain relatively high data throughput rates. In one configuration of this sixth alternative embodiment, the Baseband subsystem **502** is reconfigured to synthesize the MIMO signals as at least some of the N digital Baseband signals **55***a***1** & **55***a***2** and **55**N**1** & **55**N**2**, upon exercising the assignment based on the second criterion.

In a seventh alternative embodiment of the Dynamic Assignment embodiment, there is a wireless Base Station (BS) system **100***b*, operative to assign dynamically a plurality of radio transceiver chains **533***a*-**533**N among a varying number of wireless channels **555***a*-**555**N. In this system, at least one of the antennas **577***a*-**577**N connected to the N radio transceiver chains **533***a*-**533**N is an omni-directional antenna, and any wireless channel **555***a*-**555**N propagated by an omni-directional channel can span substantially a 360 degree coverage area around the wireless BS, regardless of an assignment of radio transceiver chains **533***a*-**533**N among the wireless channels **555***a*-**555**N.

FIG. **15**A illustrates one embodiment of a system state at a particular point of time. In FIG. **15**A, there is a Baseband subsystem **502**, which includes a Synthesis of Baseband signals **56***a*, which synthesizes N number of signals **56***a***1**, **56***a***2**, **56***a***3**, through **56***a*N, sent to N number of radio transceiver chains **533***a*-**533**N. These signals are then conveyed by the radio transceiver chains over a single wireless channel **556***a* associated with a particular frequency range **710***a*. FIG. **15**A shows an initial state, or in other words an initial phase, of an operation, during which there is communication with a group of wireless Subscriber Stations **777***d* located relatively distantly from the radio transceiver chains **533***a*-**533**N. The system state in FIG. **15**A is a two-way system, as are all the system FIGS. **10**A, **10**C, and **11**. The uplink path from **777***d* to **502** conveys signals in an order opposite from that of the downlink path. This initial state or initial phase of system operation is illustrated in FIG. **15**A may be called a "range extension mode".

FIG. **15**B illustrates one embodiment of a system state at a point of time that is different from the point of time illustrated in FIG. **15**A. In **15**B, there is a Baseband subsystem **502**, which includes a Synthesis of digital Baseband signals **55***a* and **55**N, which synthesizes N number of signals **55***a***1** & **55***a***2** associated with **55***a* and **55**N**1** & **55**N**2** associated with **55**N, sent to N number of radio transceiver chains **533***a*-**533**N. These signals are then conveyed by the radio transceiver chains over K number of wireless channels **555***a* and **555**K, associated with particular frequency ranges, **710***a* and **710**K, respectively. FIG. **15**B, shows a later state, or in other words a later phase, of an operation, during which there is communication with K groups of wireless Subscriber Stations, **777***n***1** using frequency range **710***a*, and **777***n***2** using frequency range **710**K, respectively. These two groups are located relatively nearby to the radio transceiver chains **533***a*-**533**N. The system state in FIG. **15**B is a two-way system, as are all the system FIGS. **10**A, **10**C, and **11**. The uplink paths from **777***n***1** to **502** and from **777***n***2** to **502**, convey signals in an order opposite from that of the downlink paths. The subsequent state or subsequent phase illustrated in FIG. **15**B may be called an "enhanced capacity mode".

There is a transition in time from FIG. **15**A to FIG. **15**B. Initially, the system can achieve long-range communication for a relatively few number of Subscriber Stations. In the range extension mode, the system does not discriminate against nearby Subscriber Stations, so that there is communication with both relatively distant and relatively nearby Subscriber Stations, but one feature of the system is that it can communicate with relatively distant Subscriber Stations. In a subsequent stage called the enhanced capacity mode, system utilization has increased, the system communicates with more Subscriber Stations, but these Subscriber Stations are located relatively nearby to the radio transceiver chains. Greater capacity is achieved in the enhanced capacity mode by increasing the number of wireless channels, and hence decreasing the number of signals on each channel, all without

increasing hardware or system resources. Greater capacity is achieved by eliminating or at least inhibiting communication between the radio transceiver chains and relatively distant Sub scriber Stations. Switching between range extension mode and enhanced capacity mode is dynamic, and may change relatively rapidly in accordance with available system resources and relative Subscriber Station demand at any particular point in time.

FIG. **16** illustrates a flow diagram describing one method for transitioning from a range extension mode to an enhanced capacity mode in a wireless Base Station **100***b*. In step **1041**, a wireless Base Station **100***b* assigning N radio transceiver chains **533***a*-**533**N to a first wireless channel **556***a* associated with a first frequency range **710***a*. In step **1042**, the wireless Base Station **100***b* communicating data wirelessly during an initial operation phase, with distant Subscribed Stations **777***d*, over the first wireless channel **556***a*, via the N radio transceiver chains **533***a*-**533**N, thereby utilizing the aggregated transmission power and the aggregated reception capability of the N radio transceiver chains **533***a*-**533**N to reach the distant Subscriber Stations **777***d*. In step **1043**, the wireless Base Station **100***b* stopping communication with the distant Subscriber Stations **777***d* at the end of the initial operation phase. In step **1044**, the wireless Base Station **100***b* assigning a first subset **533***a* & **533***b* of the N radio transceiver chains to a first wireless channel **555***a* associated with a the first frequency range **710***a*, and a second subset **533***c* & **533**N of the N radio transceiver chains to a second wireless channel **555**K associated with a second frequency range **710**K. In step **1045**, the wireless Base Station **100***b* wirelessly communicating data with nearby Subscriber Stations **777***n***1** & **777***n***2**, over the first **555***a* and second **555**K wireless channels, respectively, via the first subset **553***a* & **555***b* and second subset **555***c* & **555**K of the N radio transceiver chains, respectively, thereby utilizing the aggregated spectrum of the first and second frequency ranges to enhance data capability of the wireless Base Station.

An alternative embodiment of the method immediately described further includes using an N-level coherent-phase transmission scheme over the N radio transceiver chains **533***a*-**533**N to communicate data wirelessly via the first wireless channel **555***a* during the initial operation phrase.

A particular configuration of the alternative embodiment of the method described above includes using an N-level combining-algorithm such as Phased-array coherent reception, MRC, MMSE and ML, in order to utilize the aggregated reception capability of the N radio transceiver chains **533***a*-**533**N during the initial operation phase.

In a further refinement of the particular configuration of the alternative embodiment of the method described above, further including, when the initial operation phase has ended, stopping use of the N-level coherent-phase transmission scheme and the N-level combining-algorithm, and starting use of MIMO transmission and reception schemes for at least one of the first **555***a* and second **555**K wireless channels.

FIG. **17** illustrates one embodiment of components comprising a system for direct communication between multiple Core Networks and a wireless Base Station (BS), and between the wireless BS and multiple Radio Access Networks (RANs). Wireless Base Station (BS) **100***c* communicates over a backhaul link **105** and network **101** with a plurality of data sources, including at least a First Core Network data source **102***a* and a Second Core Network data source **102***b*. The wireless BS **100***c* also generates a First Radio Access Network **809***a*, which includes wireless Subscriber Stations **808**, and a Second RAN **809***b*.

FIG. **18**A illustrates one embodiment of a point in time during which two radio transceiver chains have been allocated over one channel to a first RAN, and two other radio transceiver chains have been allocated over a second channel to a second RAN. Wireless Base Station **100***c* includes one or more network processors **201***c*, one or more Baseband Processors **502***c*, and three or more radio transceiver chains **833***a*, **833***b*, **833***c*, and **833**N. A First Core Network data source **102***a* communicates a first data set **900***a* to the wireless Base Station **100***c*, which is then processed by the network processor **201***c* and the Baseband Processor **502***c*. A Second Core Network data source **102***b* communicates a second data set **900***b* to the wireless Base Station **100***c*, which is then processed by the network process **201***c* and the Baseband Processor **502***c*. The Baseband Processor **502***c* includes a plurality of syntheses of signals, here a first synthesis of signals **955***a* and a second synthesis of signals **955**N. Each synthesis of signals will generate one or multiple signals to be conveyed over one or more radio transceiver networks to a RAN. At the point of time illustrated in FIG. **18**A, synthesis **955***a* creates two signals which wirelessly convey the first data set **901***a* using each of two radio transceiver chains **833***a* and **833***b*, over a first RAN **809***a*, to a group of Subscriber Stations **808***a*. Substantially simultaneously, **955**N creates two signals that wirelessly convey the second data set **901***b* using each of two radio transceiver chains **833***c* and **833**N, over a second RAN **809***b*, to a group of Subscriber Stations **808***b*.

FIG. **18**B presents one embodiment of a Baseband Processor **502***c* and the associated radio transceiver chains. In FIG. **18**B, synthesis of signals **955***a* creates two signals. One signal, signal **955***a***1**, is conveyed to a radio transceiver chain **833***a*, then to an antenna **977***a*, then wirelessly conveying a first data set **901***a* to a first RAN. A second signal created by **955***a* is signal **955***a***2**, which is conveyed to a radio transceiver chain **833***b*, then to an antenna **977***b*, then wirelessly conveying the first data set **901***a* to a first RAN. Substantially simultaneously, synthesis of signals **955**N creates two signals. One signal, signal **955N1**, is conveyed to a radio transceiver chain **833***c*, then to an antenna **977***c*, then wirelessly conveying a second data set **901***b* to a second RAN. A second signal created by **955**N is signal **955N2**, which is conveyed to a radio transceiver chain **833**N, then to an antenna **977**N, then wirelessly conveying the second data set **901***b* to a second RAN.

For FIGS. **18**A and **18**B, it may be appreciated that there must be at least a plurality of RANs, but there may be two RANs or any other number higher than two. FIGS. **18**A and **18**B illustrate an embodiment in which there are four radio transceiver chains, but there may be three such chains, four chains, or any number higher than four, provided that each of a plurality of RANs has at least one radio transceiver chain, and at least one of said plurality of RANs has two or more radio transceiver chains at a particular moment in time.

FIG. **19**A illustrates one embodiment of a point in time during which three radio transceiver chains have been allocated over one channel to a first RAN, and one other radio transceiver chain has been allocated over a second channel to a second RAN. Wireless Base Station **100***c* includes one or more network processors **201***c*, one or more Baseband Processors **502***c*, and three or more radio transceiver chains **833***a*, **833***b*, **833***c*, and **833**N. A First Core Network data source **102***a* communicates a first data set **900***a* to the wireless Base Station **100***c*. A Second Core Network data source **102***b* communicates a second data set **900***b* to the wireless Base Station **100***c*. The Baseband Processor **502***c* includes a plurality of syntheses of signals, here a first synthesis of signals **956***a* and a second synthesis of signals **956**N. Each synthesis of signals will generate one or multiple signals to be conveyed over one

more radio transceiver networks to a RAN. At the point of time illustrated in FIG. **19**A, synthesis **956***a* creates three signals which wirelessly convey the first data set **901***a***2** using each of three radio transceiver chains **833***a*, **833***b*, and **833***c*, over a first RAN **809***a*, to a group of Subscriber Stations **808***a*. Substantially simultaneously, **956**N creates one signal that wirelessly conveys the second data set **901***b***2** using one radio transceiver chain **833**N, over a second RAN **809***b*, to a group of Subscriber Stations **808***b*.

FIG. **19**B presents one embodiment of a Baseband Processor **502***c* and the associated radio transceiver chains. In FIG. **19**B, synthesis of signals **956***a* creates three signals. One signal, signal **956***a***1**, is conveyed to a radio transceiver chain **833***a*, then to an antenna **977***a*, then wirelessly conveying a first data set **901***a***2** over a first RAN. A second signal created by **956***a* is signal **956***a***2**, which is conveyed to a radio transceiver chain **833***b*, then to an antenna **977***b*, then wirelessly conveying the first data set **901***a***2** over the first RAN. A third signal created by **956***a* is signal **956***a***3**, which is conveyed to a radio transceiver chain **833***c*, then to an antenna **977***c*, then wirelessly conveying the first data set **9901***a***2** over the first RAN. Substantially simultaneously, synthesis of signals **956**N creates one signal, signal **956**N**1**, which is conveyed to a radio transceiver chain **833**N, then to an antenna **977**N, then wirelessly conveying a second data set **901***b***2** over a second RAN.

For FIGS. **19**A and **19**B, it may be appreciated that there must be at least a plurality of RANs, but there may be two RANs or any other number higher than two. FIGS. **19**A and **19**B illustrate an embodiment in which there are four radio transceiver chains, but there may be three such chains, four chains, or any number higher than four, provided that each of a plurality of RANs has at least one radio transceiver chain, and at least one of said plurality of RANs has two or more radio transceiver chains at a particular moment in time.

FIGS. **18**A and **18**B illustrate one embodiment of a system at a particular point in time. FIGS. **19**A and **19**B illustrate one embodiment of the same system at a different point of time. In the first point in time, four radio transceiver chains have been allocated, two chains to each of two RANs. In the second point of time, four radio transceiver chains have been allocated, three chains to a first RAN and one chain to a second RAN.

It may be appreciated that there must be at least three radio transceiver chains in all embodiments. The reason is that all embodiments include (1) at least two operating RANs, and all embodiments include (2) an ability to re-allocate at least one RAN from one Operator to another Operator. As to (1), A radio transceiver chain is part of the infrastructure that creates the RAN, so that a RAN can exist only if at least one radio transceiver chain is allocated to it. Since all embodiments include at least two RANs, and each RAN must have at least one radio transceiver chain, hence every embodiment will include at least two radio transceiver chains to create the at least two RANs. As to (2), all embodiments have the potential to switch at least one radio transceiver chain from one Operator to another Operator, hence every embodiment will include at least three radio transceiver chains. Indeed, FIGS. **18**A and **18**B show a configuration at one point in time, while FIGS. **19**A and **19**B show the same system at a different point of time in which one of the radio transceiver chains, **833***c*, has been re-allocated from the second RAN to the first RAN.

In one embodiment, a wireless Base Station (BS) **100***c* system is operative to communicate directly with multiple Core Network data sources **102***a* & **102***b* on one side and directly provided multiple corresponding Radio Access Networks (RANs) **809***a* and **809***b* on the other side. Such a system may include a network processor **201***c* operative to communicate with a first and a second Core Network data sources **102***a* and **102***b*, at least one Baseband Processor **502***c* operative to create first and second RANs **809***a* & **809***b* substantially simultaneously, and a pool of at least three radio transceiver chains **833***a*, **833***b*, **833***c*, and **833**N operative to accommodate the at least one Baseband Processor **502***c* in creating the first and second RANs **809***a* and **809***b* substantially simultaneously. Such a system may allocate dynamically the pool of the at least three radio transceiver chains **833***a*, **833***b*, **833***c*, and **833**N, between the first and second RANs **809***a* and **809***b* according to a criterion, reconfigure the at least one Baseband Processor **502***c* to maintain the first and second RANs **809***a* and **809***b* according to the recent allocation, and operate the first and second RANs **809***a* and **809***b* using data communicated with the first and second Core Network data sources **102***a* and **102***b*, respectively.

In one alternative embodiment of such a system, the criterion may be based on dynamic data rate requirements of at least one of the Core Network data sources **102***a* and **102***b*, such that when the dynamic data rate requirements of the first Core Network data source **102***a* exceed the dynamic data rate requirements of the second Core Network data source **102***b*, more radio transceiver chains of those available in the system **833***a*, **833***b*, **833***c*, and **833**N, are allocated to the first RAN **809***a* as compared to the second RAN **809***b*. In one configuration of this alternative embodiment, at least one of the radio transceiver chains **833***a*, **833***b*, **833***c*, and **833**N that have been allocated to at least one of the RANs **809***a* and **809***b* convey Multiple Input Multiple Output (MIMO) signals **955***a***1** and **955***a***2**.

In a second alternative embodiment of the wireless Base Station (BS) **100***c* system operative to directly communicate with multiple Core Network data sources **102***a* & **102***b* on one side and directly provided multiple corresponding Radio Access Networks (RANs) **809***a* and **809***b* on the other side, the criterion is based on measuring data rates over at least one of the RANs **809***a* and **809***b*, such that more of the radio transceiver chains **833***a*, **833***b*, **833***c*, and **833**N, are allocated to the first RAN **809***a* as compared to the second RAN **809***b*, as a result of measuring higher data rates over the first RAN **809***a* as compared to the second RAN **809***b*. In one configuration of this alternative embodiment, at least one of the radio transceiver chains **833***a*, **833***b*, **833***c*, and **833**N, allocated to at least one of the RANs **809***a* and **809***b* convey Multiple Input Multiple Output (MIMO) signals.

In a third alternative embodiment of the wireless Base Station (BS) **100***c* system operative to directly communicate with multiple Core Network data sources **102***a* & **102***b* on one side and directly provided multiple corresponding Radio Access Networks (RANs) **809***a* and **809***b* on the other side, the criterion is based on system gain requirements of the RANs **809***a* and **809***b*, such that when the first RAN **809***a* requires a higher system gain than the system gain required by the second RAN **809***b*, more radio transceiver chains are allocated to the first RAN **809***a* than to the second RAN **109***b*.

In one configuration of this alternative embodiment, the radio transceiver chains allocated to at least one of the RANs convey signals belonging to a wireless communication scheme selected from a group consisting of Phased-array coherent communication, Maximal Ratio Combining (MRC), Minimum Mean Square Error (MMSE) and Maximum Likelihood (ML).

In a fourth alternative embodiment of the wireless Base Station (BS) **100***c* system operative to directly communicate with multiple Core Network data sources **102***a* & **102***b* on one side and directly provided multiple corresponding Radio

Access Networks (RANs) **809***a* and **809***b* on the other side, reconfiguring the at least one Baseband Processor to maintain the first and second RANs **809***a* and **809***b* according to the recent allocation, further includes performing first and a second signal syntheses **955***a* and **955**N, or **956***a* and **956**N, by the at least one Baseband Processor, in which the first synthesis is associated with the first RAN **809***a* and the second synthesis is associated with the second RAN **809***b*, and in which each sign synthesis creates at least one baseband signal, one of **955***a***1**, **955***a***2**, **955**N**1**, or **955**N**2** in FIG. **18**B, or one of **956***a***1**, **956***a***2**, **956***a***3**, or **956***a*N in FIG. **19**B, according to the allocation of radio transceiver chains among the RANs **809***a* and **809***b*.

There are at least two alternative configurations to the fourth alternative embodiment just described. In one alternative configuration, the first signal synthesis **955***a* or **956***a* synthesizes at least two baseband signals, and the at least two baseband signals belong to a wireless communication scheme selected from a group consisting of Phased-array coherent communication, Maximal Ratio Combining (MRC), Minimum Mean Square Error (MMSE) and Maximum Likelihood (ML).

In a second alternative configuration to the fourth alternative embodiment just described, at least the first signal synthesis **955***a* or **956***a* synthesizes at least two baseband signals, and these at least two baseband signals are Multiple Input Multiple Output (MIMO) signals.

FIG. **20** is a flow diagram illustrating one method for dynamically generating a plurality of Radio Access Networks (RANs) **809***a* & **809***b* by a single wireless Base Station (BS) **100***c*. In step **1051**, determining dynamically a first number of radio transceiver chains and a second number of radio transceiver chains needed by a wireless BS **100***c* to convey wirelessly data communicated with a first corresponding Core Network data source **102***a* and a second corresponding Core Network data source **102***b*. In step **1052**, allocating the first and the second numbers of radio transceiver chains, out of a pool of radio transceiver chains **833***a*-**833**N belonging to the wireless BS **100***c*, to a first RAN **809***a* and a second RAN **809***b* of the wireless BS **100***c*, respectively. In step **1053**, communicating, by the wireless BS **100***c*, a first and a second data sets with the first Core Network **102***a* and the second Core Network **102***b* data sources respectively. In step **1054**, conveying wirelessly, by the wireless BS **100***c*, to a first set **808***a* and a second set **808***b* of wireless Subscriber Stations (SS), the first and the second data sets, over the first and the second RANs respectively.

An alternative embodiment of the method just described, further comprising determining from time to time the first and second numbers of radio transceiver chains needed by the wireless BS **100***c* to convey wirelessly the first and second data sets, and allocating from time to time the first and second numbers of radio transceiver chains.

One possible configuration of the alternative embodiment just described is such alternative embodiment, further comprising determining the first and the second number of radio transceiver chains according to first and second data rate associated with communicating the first and second data sets, respectively. One possible permutation of this configuration further comprises measuring the first and second data rates. A second possible permutation of this configuration further comprises querying the first **102***a* and second **102***b* Core Network data sources for the first and second data rates, respectively.

A second possible configuration of the alternative embodiment just described is said alternative embodiment, wherein at some point in time most of the pool of radio transceiver chains is allocated to the first RAN. One possible permutation of this configuration is the configuration wherein in at some point in time most of the pool of radio transceiver chains is allocated to the second RAN.

A third possible configuration of the alternative embodiment just described is such alternative embodiment, further comprising determining the first and second numbers of radio transceiver chains according to a first distance of Subscriber Stations (SS) from the wireless BS **100***c*, and a second distance of Subscriber Stations from the wireless BS, respectively.

A second alternative embodiment to the method described is said method, further comprising communicating the first and second data sets with the first **102***a* and second **102***b* Core Network data sources using at least one Backhaul link **105**.

One possible configuration of this second alternative embodiment is said second alternative embodiment, wherein the at least one Backhaul link **105** comprises a first network Tunnel connecting the first Core Network data source **102***a* with the wireless BS **100***c*, and a second network Tunnel connecting the second Core Network data source **102***b* with the wireless BS **100***c*. One possible permutation of this configuration of the second alternative embodiment is said second alternative embodiment, in which the wireless BS **100***c* is an integrated Pico-BS, having the network Tunnels directly connected to the first **102***a* and second **102***b* Core Network data sources, and the Pico-BS substantially does not require a dedicated infrastructure to facilitate connectivity with the Core Networks data sources **102***a* & **102***b* other than the at least one Backhaul link **105** and an network **101** comprising the Core Network data sources **102***a* & **102***b*.

A second possible configuration of the second alternative embodiment is the second alternative embodiment, in which the first data set is communicated over the first Backhaul link and the second data set is communicated over a second Backhaul link.

A third alternative embodiment to the method described is said method, in which the first Core Network data source **102***a* belongs to a first Operator, the second Core Network data source **102***b* belongs a second Operator, the first RAN **809***a* is associated with an identity of the first Operator, and the second RAN **809***b* is associated with the identity of the second Operator.

FIG. **21** is a flow diagram illustrating one method for servicing multiple Operators via a single wireless Base Station (BS) **100***c*, utilizing dynamic allocation of radio transceiver chains. In step **1061**, a wireless BS **100***c* communicating first and second data sets **900***a* & **900***b* with a first Core Network data source **102***a* belonging to a first Operator and with a second Core Network data source **102***b* belonging to a second Operator, respectively. In step **1062**, the wireless BS **100***c* conveying wirelessly, to a first set and a second set of wireless Subscriber Stations (SS) **808***a* & **808***b*, the first and the second data sets, respectively, over a first and a second RAN, respectively **809***a* & **809***b*, utilizing a first set **833***a* & **833***b* and a second set **833***c* & **833**N of radio transceiver chains, respectively. In Step **1063**, determining that the first set of radio transceiver chains is not sufficient to convey the first data set. In Step **1064**, increasing the number of radio transceiver chains in the first set, at the expense of the second set, thereby making the first set better suited to convey the first data set.

One alternative embodiment to the method just described is the method, in which increasing the number of radio transceiver chains in the first set further comprises determining the number of radio transceiver chains that can be reduced from the second set of radio transceiver chains without substan-

tially impairing the ability of the second set of radio transceiver chains to convey the second data set, reducing the number of radio transceiver chains from the second set of radio transceiver chains and adding the number of radio transceiver chains to the first set of radio transceiver chains.

A second alternative embodiment to the method for servicing multiple Operators via a single wireless Base Station utilizing dynamic allocation of radio transceiver chains, is such method in which the number of radio transceiver chain in the first set further comprises determining a number of radio transceiver chains to be reduced from the second set of radio transceiver chains and to be added to the first set of radio transceiver chains such that the number of radio transceiver chains is operative to substantially equate the ability of the first set of radio transceiver chains to convey the first data set with the ability of the second set of radio transceiver chains to convey the second data set, reducing the number of radio transceiver chains from the second set of radio transceiver chains, and adding the number of radio transceiver chains to the first set of radio transceiver chains.

In this Detailed Description, numerous specific details are set forth. However, the embodiments of the invention may be practiced without some of these specific details. In other instances, well-known hardware, software, materials, structures and techniques have not been shown in detail in order not to obscure the understanding of this description. In this description, references to "one embodiment" mean that the feature being referred to may be included in at least one embodiment of the invention. Moreover, separate references to "one embodiment" or "some embodiments" in this description do not necessarily refer to the same embodiment. Illustrated embodiments are not mutually exclusive, unless so stated and except as will be readily apparent to those of ordinary skill in the art. Thus, the invention may include any variety of combinations and/or integrations of the features of the embodiments described herein. Although some embodiments may depict serial operations, the embodiments may perform certain operations in parallel and/or in different orders from those depicted. Moreover, the use of repeated reference numerals and/or letters in the text and/or drawings is for the purpose of simplicity and clarity and does not in itself dictate a relationship between the various embodiments and/or configurations discussed. The embodiments are not limited in their applications to the details of the order or sequence of steps of operation of methods, or to details of implementation of devices, set in the description, drawings, or examples. Moreover, individual blocks illustrated in the figures may be functional in nature and do not necessarily correspond to discrete hardware elements. While the methods disclosed herein have been described and shown with reference to particular steps performed in a particular order, it is understood that these steps may be combined, sub-divided, or reordered to form an equivalent method without departing from the teachings of the embodiments. Accordingly, unless specifically indicated herein, the order and grouping of the steps is not a limitation of the embodiments. Furthermore, methods and mechanisms of the embodiments will sometimes be described in singular form for clarity. However, some embodiments may include multiple iterations of a method or multiple instantiations of a mechanism unless noted otherwise. For example, when an interface is disclosed in an embodiment, the scope of the embodiment is intended to cover also the use of multiple interfaces. Certain features of the embodiments, which may have been, for clarity, described in the context of separate embodiments, may also be provided in various combinations in a single embodiment. Conversely, various features of the embodiments, which may have been, for brevity, described in the context of a single embodiment, may also be provided separately or in any suitable sub-combination. Embodiments described in conjunction with specific examples are presented by way of example, and not limitation. Moreover, it is evident that many alternatives, modifications and variations will be apparent to those skilled in the art. It is to be understood that other embodiments may be utilized and structural changes may be made without departing from the scope of the embodiments. Accordingly, it is intended to embrace all such alternatives, modifications and variations that fall within the spirit and scope of the appended claims and their equivalents.

What is claimed is:

**1**. A wireless Base Station (BS) system to assign dynamically a plurality of radio transceiver chains among a number of wireless channels, comprising:

a Base-Band (BB) subsystem comprising a plurality of digital ports, said BB subsystem used to synthesize a plurality of digital BB signals associated with said number of wireless channels, said number of wireless channels less than or equal to a number of said digital BB signals;

a plurality of analog-digital interfaces, wherein each of said plurality of radio transceiver chains connects to one of said plurality of digital ports of the BB subsystem via one of the plurality of analog-digital interfaces; and

further wherein the system

sets the number of wireless channels dynamically according to a first criterion,

assigns the plurality of radio transceiver chains dynamically among the number of wireless channels according to a second criterion, such that each radio transceiver chain is assigned to only one of the wireless channels,

synthesizes, using the BB subsystem, the plurality of digital BB signals associated with the number of wireless channels, and

inputs the plurality of digital BB signals to the plurality of radio transceiver chains via the corresponding plurality of digital ports and the corresponding analog-digital interfaces, thereby transmitting the number of wireless channels via the plurality of radio transceiver chains.

**2**. A method for transitioning from a range-extension-mode to an enhanced-capacity-mode in a wireless Base Station (BS), comprising:

assigning, by said wireless BS, one or more radio transceiver chains to a first wireless channel associated with a first frequency range;

communicating data wirelessly during an initial operation phase, by the wireless BS, with distant Subscribed Stations (SS), over the first wireless channel, via the one or more radio transceiver chains, thereby utilizing an aggregated transmission power and an reception capability of the one or more radio transceiver chains to reach the distant SS;

stopping communication, by the wireless BS, with the distant SS at the end of the initial operation phase;

assigning respectively, by the wireless BS, first and second mutually-exclusive subsets of the one or more radio transceiver chains to the first wireless channel associated with the first frequency range, and a second wireless channel associated with a second frequency range respectively; and

communicating data wirelessly, by the wireless BS, with near-by Subscribed Stations (SS), over the first and sec-

ond wireless channels, via the first and second mutually-exclusive subsets respectively.

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